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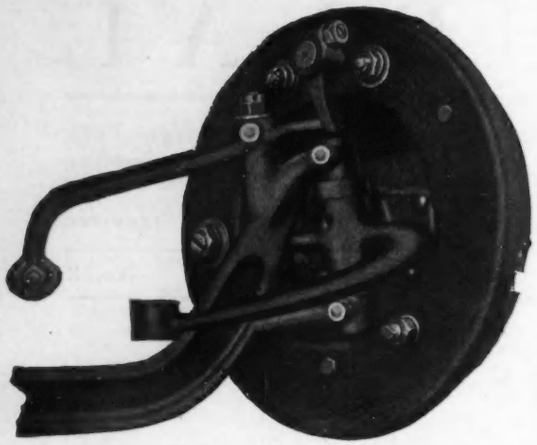
The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.



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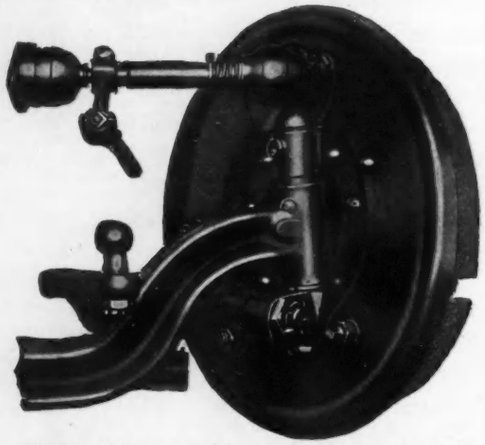

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Hudson Super Six	Star Car Six	Studebaker Coaches
Lincoln	Stearns-Knight Six	Trailmobile
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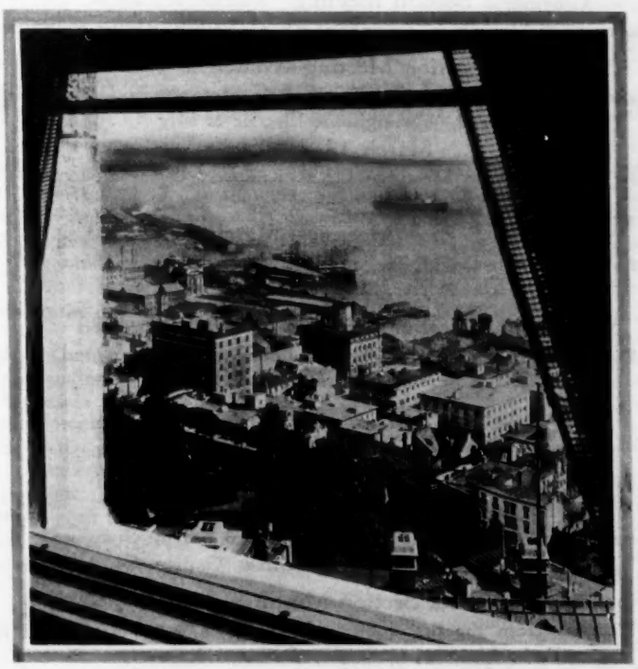
Progress of Summer Meeting Plans

Quaint Quebec To Be the Locale of an Enjoyable Occasion from June 26 to 29—Other National Meetings Outlined

June 26 may seem to be as yet a comparatively remote date. It is not so far in the future, however, as to make it inappropriate to give at this time some consideration to the Summer Meeting which will open on that date in the picturesque and historic city of Quebec.

A meeting held in the spring or early summer may, and often does, comprise as many professional sessions as a meeting held at some other time of the year, and the sessions may be quite as technical in character. But something in the nature of man or, it may be, his present stage of development, makes it desirable, if not absolutely imperative, that a spring or summer meeting be held in a setting materially different from that which is accepted as appropriate for a fall or a winter gathering. Summer-time calls for nearness to the out-of-doors; it demands that beauty and freshness of scene be accessible.

Recognizing this fact, the Meetings Committee has always endeavored to stage the Society's Summer Meeting in attractive surroundings. In finding a suitable place for the 1928 Summer Meeting, the Meetings Committee consulted the Society's membership, and the resultant vote showed that Quebec was the site preferred.



A VIEW FROM CHATEAU FRONTENAC

Chateau Frontenac, with a total capacity of 1500, will house the meeting, which will be held June 26 to 29, inclusive. The Chateau, rising from Dufferin Terrace, 200 ft. above the St. Lawrence River, occupies one of the highest points in Quebec and commands an incomparable view. Two excellent 18-hole golf courses are within a 15-min. automobile ride of the Chateau, and tennis courts can be reached in 5 min.

The program has not yet crystallized into sessions, although the wealth of technical data that will be available in time for presentation at the Summer Meeting will be more than enough to provide interesting sessions for the four days. One session that has already been outlined and that unquestionably will make a wide appeal will be devoted to a consideration of Canadian transportation. The cooperation of Canadian experts has been promised, thus assuring the success of the session, which will deal with transportation by air as well as by highway.

Several distinguished European engineers have accepted the Society's invitation to attend the meeting, and a number of papers dealing with important developments abroad have been promised. Members who recall the interesting papers and addresses presented by foreign members and guests at recent Annual and Semi-Annual Meetings will look forward with eager anticipation to the European contributions to the forthcoming Summer Meeting.

Many inquiries have already been received, from members who are planning to attend the Summer Meeting, with regard to the cost of the trip, the amount of time to be consumed in the journey, and details about accommodations *en route*. Arrangements are now being made for special trains to take the members and their guests to Quebec, and a *Meetings Bulletin* will be published at an early date giving the necessary information about transportation facilities.

Besides the Summer Meeting, the Meetings Committee, under the chairmanship of John A. C. Warner, has planned the following National events to be held during the current administrative year: an Aeronautic, a Production, and an Automotive Transportation Meeting, the time and the place for each of these three meetings to be announced later; the Annual Dinner, which will be held at New York City in January, 1929, during the Automobile Show Week; and the Annual Meeting, which will be held at Detroit, late in January, during the week immediately preceding the Chicago Automobile Show.

Each meeting will be sponsored by a committee under the chairmanship of a prominent member particularly interested in the topic covered by the meeting that is to be arranged under his direction. An announcement regarding these chairmen and their committees will be made at a later date.

Meetings Calendar

Summer Meeting
June 26 to 29, 1928
Chateau Frontenac, Quebec

Sections Calendar

Buffalo Section Meeting—March 6, 1928
Diesel Engines—O. D. Treiber, Treiber Diesel Engine Corporation

Chicago Section Meeting—March 13, 1928
Motors for Gas-Electric Motorcoach Drives—C. A. Atwell, Westinghouse Electric & Mfg. Co. Prepared Discussion by A. W. Scarratt, International Harvester Co.

Cleveland Section Meeting—March 12, 1928
Importance of Mechanical Inventions—F. O. Richey, Richey & Watts

Detroit Section Meeting—March 5, 1928
Generators and Motors for Gas-Electric Motorcoach Drives—C. A. Atwell, Westinghouse Electric & Mfg. Co.

March 19, 1928
First Body Division Meeting—O. T. Kreusser, General Motors Corporation

Indiana Section Meeting—March 8, 1928
Superchargers—David Gregg, A. C. Spark Plug Co., and Louis Schwitzer, Schwitzer-Cummins Co.

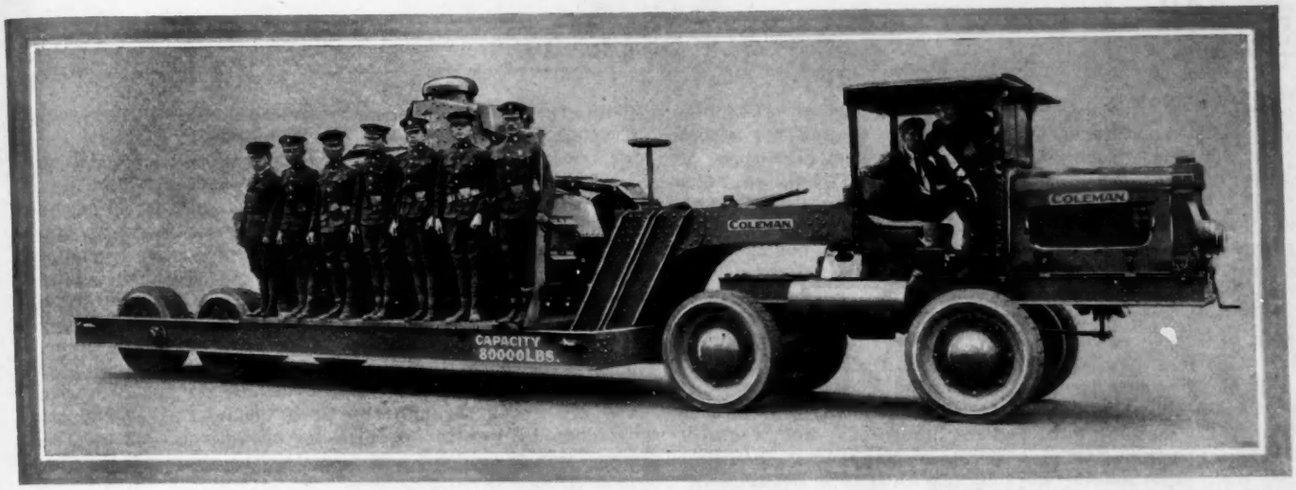
Metropolitan Section Meeting—March 28, 1928
Diesel Engines—H. D. Hill, Hill Diesel Engine Co., and C. L. Cummins, Cummins Engine Co.

Milwaukee Section Meeting—March 7, 1928
Notes on Automotive Development in Europe—J. B. Fisher, Waukesha Motor Co.

New England Section Meeting—March 7, 1928
Construction and Operation of Garages and Service Stations—Glenn L. Whitham, Charles Street Garage Co.

Northern California Section Meeting—March 8, 1928
Brakes from the Standpoint of the Fleet Operator—F. R. Maulsby, American Railway Express
Servicing Brakes—F. C. Stanley, Raybestos Co.
Cause of Brake-Lining Failure—John H. Watrous, Ferodo & Asbestos, Inc.

Pennsylvania Section Meeting—March 13, 1928
Alloy Steels as Applied to the Automotive Industry—B. Egeberg, International Silver Co.



ARMY TRACTOR AND TRAILER HAULING A WHIPPET TANK

In Future Wars Machine-Gun Tanks Are Expected To Be Hauled to the Front by Tractors or Tractor-Trucks, Thereby Making the Fighting Units More Mobile

Milwaukee Told of Army Needs

Major W. F. Rockwell Informs the Section of Special Vehicle Types Required and How Civilians Can Help

"If motor-vehicles are provided which can travel at high speed on the roads and still have the ability to traverse off-road areas, motor transport will be much more reliable than rail transport under the same conditions of air attack," asserted Major W. F. Rockwell in an address on Progress in Military Motor Transport, at the regular monthly meeting of the Milwaukee Section held Feb. 1 at the Milwaukee Athletic Club.

Some recent developments in six-wheel trucks and auxiliary track equipment seem to indicate the lines along which efforts will continue to be made to supply this need. Too little commercial need exists, however, to warrant much development work by manufacturers, and, although the Quartermaster Corps has the talent and the desire to do the experimental work, no appropriation for it has been made by the Congress. To make progress in this field it is necessary that civilians urge upon their representatives in the City of Washington the appropriation of funds specifically for the purpose.

Major Rockwell, who is an officer in the Quartermaster Reserve Corps and also president of the Wisconsin Parts Co. and of the Pittsburgh Equitable Meter Co., gave a most interesting and informative talk to the 40 members of the Section who attended the meeting and a number of whom took part in the discussion.

A motion-picture reel showing the chassis-assembling contest at the Summer Meeting in 1927 was run off at the opening of the meeting, which was presided over by Cyrus L. Cole.

MOTOR TRANSPORT DATES FROM PHILIPPINE CAMPAIGN

In opening his address, Major Rockwell stated that the history of military motor transportation goes back to the first use of a tractor and two trailers in the Philippine Islands for hauling supplies between two camps 4½ miles apart, involving a climb of 450 ft. In 1904 some 1½-ton trucks were tested at West Point, and in 1912 officers of the Quartermaster Corps made a test run with 12 trucks from the City of Washington to Fort Benjamin Harrison, Ind., by way of Atlanta, only four of the trucks arriving at the destination, where the final tests and inspection were completed. At the beginning of the World War the Society offered its services to the War Department for making a survey of the automotive industry so that if the United States should become involved the industry might cooperate with the Army in providing such equipment as would be required. Not until 1916, however, did the War Department ask the Society to assist it in revising specifications for the 1½ and 3-ton trucks then being seriously considered by the Army. At this time extensive use was made of commercial trucks in the punitive expedition into Mexico, and experience gained in these operations proved invaluable in the World War.

FAST TRUCKS WITH AUXILIARY TRACKS NEEDED

Some military experts believe that future wars between the great powers will be won by the army which uses the largest number of fast-moving units on land and in the air, said Major Rockwell, hence the airplane and the rapid vehicle with relatively light gun equipment, very mobile and able to negotiate terrain without roads, will become the weapons for both defense and offense.

Under the National Defense Act the Quartermaster General is charged with the transportation of the Army by land and water, including the transportation of troops and supplies, and with the furnishing of means of transportation of all classes and kinds required by the Army. Included in these are many special-purpose vehicles, for the design, development and procurement of the chassis of which the Quartermaster Corps is responsible, although the providing of the special bodies and their equipment and maintenance rest with the services that make use of them. The Ordnance Department has charge of the design, procurement and operation of tanks, tractors and track-laying vehicles used for hauling or towing guns, ammunition, reel carts and similar fighting equipment.

The development of passenger cars, conventional and four-wheel-drive and six-wheel trucks, and of some tractors can be left to private manufacturers, but as there is little commercial demand for armored cars, cross-country reconnaissance cars, tanks, special types of six-wheel trucks for cross-country work and gas-electric-drive chassis, the Army is making a study of these and is doing some development work on them. The Ordnance Department has

shown great interest in six-wheel vehicles and hopes to develop special tracks to go over and around the wheels on either side. Such vehicles could travel at high speed on good roads and, when the tracks are applied, could approach tractor performance in cross-country going. More powerful engines and heavier wide-range transmissions must be provided, however. The Motor Transport Division has built a special six-wheel-drive vehicle and the Quartermaster Corps has developed a six-wheel gasoline-electric-drive vehicle in which an individual electric motor drives each of the three axles. Electric current from these latter vehicles is available for varied field uses.

In many cases, according to Major Rockwell, the four-wheel and six-wheel-drive vehicles undoubtedly will replace tractors for hauling guns and for other heavy-duty requirements. The high cost of building special tractors has limited such experimental work by the Ordnance Department. The trend in tanks is toward light weight and greater speed but the difficulty of obtaining a track design that will withstand high speed is an obstacle. The value of heavy tanks in future wars is thought to be very doubtful.

Motion pictures and many lantern slides of Army vehicles were projected on the screen to illustrate the speaker's address.

An Army Plan of Interest to Makers

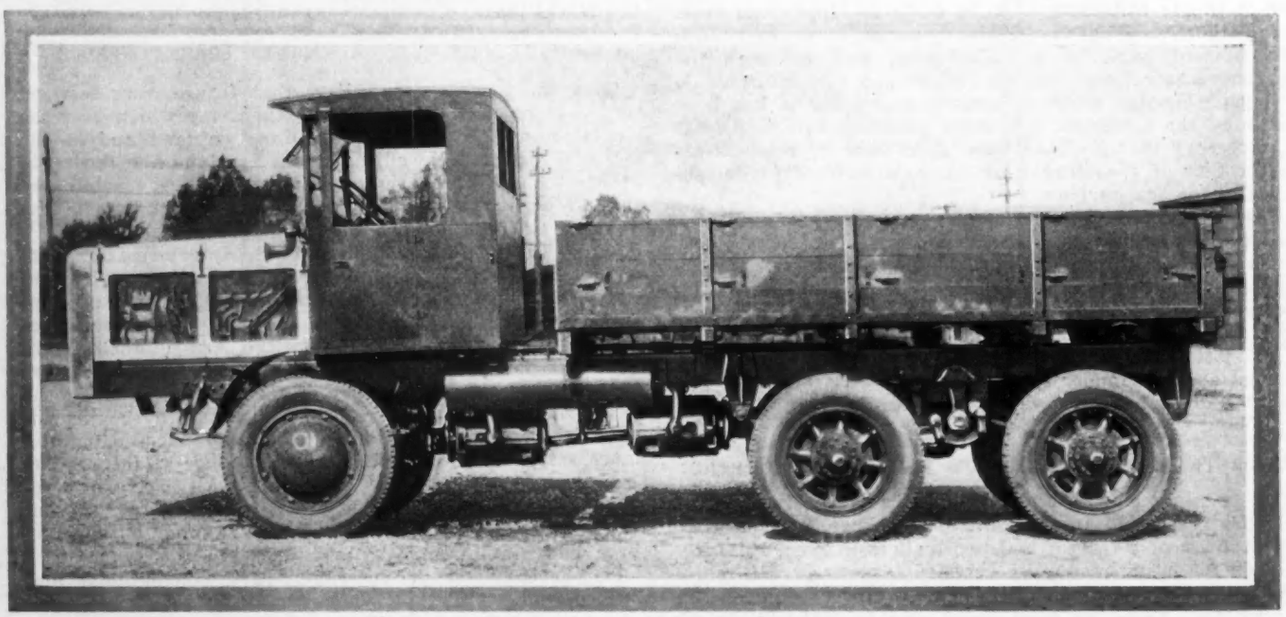
A recently announced plan of the War Department that should have the special attention of the automotive industry, said Major Rockwell, is to constitute an experimental mechanized force of regular Army units at Camp Meade during the summer of 1928 for the purpose of developing and testing the organization and equipment for the motorization and mechanization of appropriate units of the Army. It is contemplated that, although no present appropriations are available for the procurement of modern automotive equipment, this force will be equipped with motor-vehicles of the latest approved design, as manufacturers will be invited to submit their latest cars, trucks and other vehicles for test. The commanding officer at Camp Holabird has been designated to select and make ready for testing the vehicles that will be required and to confer with manufacturers desiring to have their products represented in this demonstration.

Lack of funds hampers the Army in its development work on special vehicles which it needs and for which there is at present little commercial demand yet which could find various industrial applications if the experimental work were done and manufacture begun. Army policies and plans are almost entirely subject to Congressional approval and to essential appropriations from Congress. Both the Army and the automotive industry would benefit, said Major Rockwell, if pressure were brought to bear on the Congressmen to make needed appropriations for this work, particularly if done at once, while the appropriations for the fiscal year 1930 are going through the Congress. Army officers are forbidden by law to organize for the purpose of swaying public opinion and are not permitted to approach the Congress in efforts to obtain appropriations, except through regular channels. Hence, said the speaker, if the automotive industry feels that more experimenting should be done, it must make its appeal to the Congress. The will, the energy, the ambition, and the ability to design special automotive vehicles will be found in the present group of officers who have charge of the automotive sections in the Army.

Following much interested discussion by members present, Chairman Cole asked if other Sections of the Society are taking steps to ask for such appropriations, and Major Rockwell replied that several are doing so and that if proper push were exerted the Congress would increase the appropriations and the Army would be able to buy various vehicles which it should have. Thereupon, Chairman Cole asked the secretary of the Section to bring the subject before the Governing Committee at its next meeting.

AIR-COOLED CAR FEATURES

Engineering features of the Franklin car were discussed in a paper by E. S. Marks, chief engineer of the H. H. Franklin Mfg. Co., and F. G. Shoemaker, his assistant, at the Feb. 14 meeting of the Dayton Section. Before the meeting, which was held at the Dayton Engineers' Club,



Gasoline-Electric 5-Ton Six-Wheel-Drive Army Truck

Each Axle Is Driven by a Separate Electric Motor, Giving Extraordinary Tractive Effort. Low-Pressure Tires Enable the Truck To Traverse Soft Ground. If Auxiliary Tracks Can Be Applied Successfully to the Rear Wheels of Six-Wheel Trucks, Such Vehicles Will Be Capable of High Speed on the Road and also of Taking the Place of Tractors in Cross-Country Work. Electric Current from the Gasoline-Electric Vehicle Is Available for Many Other Purposes

a dinner was tendered to Mr. Marks, and Mr. Shoemaker was given the welcome of an old friend, as he formerly was research engineer at McCook Field and was secretary of the Dayton Section last year.

Among the distinctive characteristics of the car that were discussed were direct air-cooling of the cylinders, the distributor-type oiling system, double valve-springs, positive crankcase ventilation, and the electric primer. The influence of full-elliptic springs and flexible frame construction on riding-qualities also was considered.

The Franklin car was said to be a pioneer user of seven-bearing crankshafts, case-hardened crankshaft bearing surfaces, aluminum-alloy pistons and connecting-rods, and flexible clutch centers.

Air-cooled cars were traced in their development from 1901 to the present time, and slides were given to illustrate early cars and the latest as well. The paper was followed by a number of questions and some lively discussion.

SHOW ECHOES IN INDIANA

Snow Reviews Changes in New Models—McCain Illustrates Development of a Car

After a dinner, members and guests of the Indiana Section to the number of 50 or more met in the rainbow room of the Hotel Severin at Indianapolis. A Section Nominating Committee consisting of F. F. Chandler, Fred Duesenberg, T. J. Litle, Jr., Frederick E. Moskovics, and Ralph Teetor was elected, and then R. P. Lewis, Marmon chief draftsman, read a paper on Small-Car Development that had been prepared by George L. McCain, research experimental engineer for Dodge Bros., who was unable to attend the meeting.

In his paper Mr. McCain said that appearance and style create a desire to buy but the majority of car drivers demand superior performance in cars selling for more than $700. In developing a new car to meet a certain demand it is important to analyze the cars with which it must compete.

Several charts were shown from data derived from 20 well-known cars ranging in wheelbase from 100 to 127 in. These charts compared the total price with the price per pound, the car weight with the wheelbase, the car weight with the engine speed in revolutions per mile, the engine displacement with the torque, the horsepower per cubic inch with the displacement, and the accelerating and decelerating ability.

A new car must be above the average in these features to appeal to the car-buying public, according to the author, who stated that this sort of analysis is a conservative method of anticipating public demand. With the aid of slides showing the construction of the new Dodge six-cylinder car, Mr. McCain reviewed the steps that had been taken in the design of that car to secure these results.

New Tendencies Analyzed

Then followed an engineering review of the shows, in which H. C. Snow, Auburn chief engineer, gave a remarkably comprehensive report of general tendencies and new details which he had observed at the New York and Chicago automobile shows. After general comments on points such as greater beauty, changed radiator appearance, lower actual and apparent car height, ventilators, instrument panels, and improved body details, Mr. Snow described a new type of Oakland and Pontiac radiator core into which the water from the cylinders enters at the left side and about midway of its height and passes through the core to the outlet at the lower right side. It is said to be possible to use these radiators half full of a cooling solution in winter weather, resulting in economy with an alcohol solution because any vapor is condensed instead of being lost through the overflow.

Several cars produced by the General Motors group are using a new form of compression chamber which differs from the conventional shape in three respects: (*a*) the length is greater than is customary, giving more water-jacket surface; (*b*) the chamber is very thin, especially over the piston; and (*c*) all four sides are convex, tending to throw the gases toward the center where they can be most readily ignited. The spark-plug is placed midway between the valves.

Mr. Snow described briefly the supercharger shown on the du Pont car, which feeds air through a rotary valve at the lower end of the cylinder during the last part of the opening of the regular inlet valve. This air does not go through the carbureter, but is said to increase the compression pressure to about 106 lb.

Other features mentioned by Mr. Snow were a general increase in power, sometimes obtained by increased compression, dual carbureters and improved manifolds; the use of thermostats in about nine-tenths of the cars; increased stiffness of frames; and improvements in chassis lubrication and spring shackles.

Contributions from Racing

When called upon by Chairman George H. Freers, Col. W. G. Wall, president of the Society, spoke of the influence of racing practice on stock cars, particularly in regard to eight-in-line engines, high rotative speeds, high compression and superchargers. He also mentioned the development of Diesel engines.

Fred Duesenberg said that he had particularly studied the frames of cars at the shows and had noted many improvements in details. He complimented the design of the new Studebaker frames, which he thought gave more strength per pound of weight than any other he noticed. There appears to Mr. Duesenberg a chance for economy with the type of supercharger used on the du Pont car. It is claimed that the air introduced immediately above the piston is not thoroughly mixed with the carbureted charge but is heated during the power stroke. However, he expressed the opinion that if the same effort that is required to build a satisfactory supercharger is applied to improved valve mechanism and power manifolds almost as much gain can be made at high speeds, and low-speed conditions will be better.

Real stock-car racing would be of great benefit to the industry, according to Mr. Duesenberg, and the first effect would be development of axles to make them stand up on the turns of the track without an increase in weight to produce hard riding. He recounted some old racing experience in which a heavy axle had limited the car speed and material improvement had been secured by reducing the axle weight.

Will the Four-Cylinder Car Vanish?

Stock-car racing will never be an actuality, according to T. J. Litle, Jr., until the cars are taken from the salesroom floor and driven "as is." He commented on the improved seating comfort, even in the smallest cars, but remarked that some models seem to have telephone books for seats. Mr. Litle sees an increased trend toward eight-cylinder cars, especially in the medium-price class, and prophesied that in 2 years there will be many eight-cylinder cars and none with four cylinders.

Ralph Teetor spoke of some tests on engines used by a builder of high-grade cars, the subject being suggested by the discussion of racing. In the tests several engines were run to destruction at high speed, the parts that failed first being strengthened between tests. The result was a great increase in the life of the engines, with no radical change in design. He also mentioned seeing a Miller engine in California that is expected to compete in the Speedway race at 10,000 r.p.m.

Asked for comment on the subject of four-speed transmissions, Perry L. Tenney, of the Muncie Products Corporation, told of the great economy and excellent performance he had secured in running a low-powered car about 26,000 miles with such a transmission. Nevertheless, he said that the tendency is rather to simplify operation and

avoid gear-shifting. There may be a small demand for cars with four-speed transmissions, but, according to Mr. Tenney, under the present conditions of fuel cost and popular attitude, the tendency is to use a two-speed transmission.

Chairman Freers closed the session with the announcement that the meeting in March will be devoted to superchargers as applied to the engines of the present-day passenger-cars.

Electric Drives Discussed

Pennsylvania Section Hears Papers on Electric Transmissions for Motorcoaches and Taxicabs

With an attendance between 75 and 100, the Pennsylvania Section met in Philadelphia on Feb. 14. During the dinner there were a musical sketch and impersonations by two entertainers. A Section Nominating Committee was elected also, consisting of Edward L. Clark, Henry B. Coleman, Thurman O. Day, Charles O. Guernsey, and Eugene R. Pritchard.

After the tables were cleared away, Section Chairman N. G. Shidle called to the chair E. W. Templin, who had arranged the meeting. Greetings of the Society were given to the Section by C. F. Clarkson, who recounted incidents of his recent European trip, mentioned the coming Summer Meeting in Quebec, and said that the Society should not rest satisfied with what it has done, the members should work together to accomplish more.

The main speaker of the evening was Clarence A. Atwell, engineer of the Westinghouse Electric & Mfg. Co., who read a paper on generators and motors for gas-electric motorcoach driving. In introducing Mr. Atwell, Chairman Templin recalled a meeting about 2½ years ago when the same subject was presented principally by representatives of the General Electric Co. Since that time about 500 motorcoaches with electric transmission have been installed in Philadelphia.

Improved Performance Secured

Increased acceleration, easier driving, smoother operation, and greater freedom in arranging of the units were said by Mr. Atwell to be among the advantages of the electric transmissions. The most practical arrangement is a direct-current generator with one or more entirely separate motors.

Not all electric transmissions have secured the operating qualities most desired, but it is possible to design a generator and motor so that the speed-torque characteristics of the gasoline engine are converted to give high tractive effort at low speed, with a gradually increasing speed as the tractive effort is reduced. This can be accomplished automatically with a relatively small change in engine-speed.

Curves accompanying the paper showed the torque and speed characteristics of representative engines, generators and motors, with the voltage and current of the electrical units; and diagrams showed the electrical circuits of the units. The generator field is excited mainly by a shunt, and a small battery field is provided for a positive initial building-up of the magnetic flux. It is important to proportion the field coils for the minimum of self inductance for rapid acceleration of the vehicle.

Engine characteristics should be somewhat different for an electric transmission than for a mechanical transmission. The use of a heavy flywheel is not desirable, and performance is immensely more important at high speed than at low speed.

Structural Details of Electrical Units

Commutating poles contribute to long life and freedom from sparking and flashing in the electrical units, said Mr. Atwell. An inclined position of the brush holders reduces the wear and the noise of the brushes. Light weight is secured by the use of aluminum alloy in the structural members of the units that are not a part of the magnetic circuits and by a careful provision for circulating air for cooling. A single motor has better characteristics of weight and efficiency than two motors for the same work, but two are sometimes used to reduce the floor height.

In over-all efficiency the electric transmission is not claimed to equal the mechanical transmission. However, in city work, the advantages in acceleration, comfort to passengers and ease of handling are said to more than offset the resulting increased gasoline consumption.

It has been found that passengers like better to ride in gas-electric motorcoaches, that such coaches can maintain increased schedule speed, and that relieving the driver of gear-shifting makes his job more attractive and sometimes enables him to do the work of the conductor. Greatly increased life of the vehicle is also indicated with electrical transmission.

One of the photographs with the paper showed an engine and generator mounted transversely at the rear of a motorcoach. The author emphasized the possibility of some such arrangement as this in view of the present tendency to build modified street-cars on pneumatic tires.

A Gas-Electric Taxicab Test

Following Mr. Atwell, a paper on gas-electric taxicabs was presented by Guy W. Wilson, of the railway engineering department of the General Electric Co., who contrasted the mileage ordinarily covered by a private passenger-car and by a taxicab. Taxicabs often are used by several drivers and the drivers cannot be absolutely controlled.

After several other tests, it was decided to equip a Willys-Knight model 70A chassis, having an engine of the desired size and characteristics, with an electric transmission. The electrical equipment developed and built by the General Electric Co. consisted of a shunt-wound commutating-pole generator direct connected to the engine, a series-wound commutating-pole motor direct connected to the propeller-shaft, and a suitable control for connecting the generator and motor for forward or reverse movement. The axle reduction was 9.85 to 1.

The vehicle speed is controlled by the engine throttle and the speed cannot exceed 2000 r.p.m. at any vehicle speed up to the 40-m.p.h. free-running speed of the loaded cab on level road. Without passengers the completed cab weighs approximately 3900 lb.

According to Mr. Wilson, with a total weight of 4600 lb. a speed of 10 m.p.h. can be reached from a standing start with this cab in 3 sec., 20 m.p.h. in 6 sec., and 30 m.p.h. in 12 sec. With the same weight a 17-per cent grade can be climbed at a speed of 10 m.p.h. In regular taxicab service the gasoline consumption is 13.2 miles per gal., and on a cross-country run it is 15 miles per gal.

To illustrate the flexibility and ease of operation of a gas-electric cab, Mr. Wilson told of a test in which the driver of a conventional taxicab was called upon to climb a 17-per cent grade, stopping and starting the cab several times during the ascent. After going through this performance several times with the mechanical-drive vehicle, he then was transferred to the gas-electric cab and, after the first trip, he said, "I wish I could have a cab like this to drive all the time."

In the discussion, Mr. Wilson said that about 500 lb. would be added to the weight of a cab by the electric drive and he considered the performance secured to be remarkably good for so heavy a vehicle with a comparatively small engine.

According to A. K. Brumbaugh, the White Motor Co. has delayed extensive development work on gas-electric motorcoaches pending the production of a suitable engine. It now has built such a vehicle, with a 120-hp. engine, which is said to show remarkable performance.

Another point brought out was that a generator power of more than about 70 per cent of the rated engine power should not be expected. The losses are due to air compressor, generator and other accessories and to a falling off in efficiency of the engine because it is not always kept up to the best possible condition.

Confirmation of the increased schedule speed possible was given by H. E. Hewitt, superintendent of maintenance of the Philadelphia Rural Transit Co., who claimed that the Philadelphia motorcoaches maintained the fastest schedule speed of any in the Country. He also said that he recently has been able to extend the engine inspection period from once in 8000 miles to once in 25,000 miles, and that a number of motorcoaches are operating in Philadelphia that have traveled more than 150,000 miles without a general overhauling.

Brakes Provoke Animated Discussion

More Than 300 Members and Guests Attend Southern California Meeting To Hear and Discuss Five Papers

If braking efficiency should be proportional to speed and size the Southern California Section must be speedy as well as large, judging by the interest shown in the subject of brakes and braking at the regular monthly meeting of the Section on Feb. 10, at the City Club in Los Angeles, following a members' dinner in the evening. This was a joint meeting of the Section with the Automotive Council, and preliminary notices of the meeting announced it was to be "all about brakes, a subject of vital importance."

If anything was left unsaid on the subject at the close of the meeting, it was for lack of time and not for lack of interest or for failure of the committee in charge of the meeting to arrange for a sufficiency of speakers. Five prepared papers were presented and prolonged discussion followed them. No mistake was made in announcing this as a subject of vital importance, as good brakes and brake adjustments are a matter of life and death, especially in a mountainous country.

The meeting was the largest and best the Section has held this season, with a total attendance of 312 members and guests, of whom 255 partook of the dinner. It was to have been a joint meeting also with the Service Managers Association, but the latter had a meeting of its own 2 days previously and therefore could not hold a joint meeting with the Southern California Section and the Automotive Council; nevertheless a considerable number of service managers were in attendance.

At the opening of the meeting a Nominating Committee was elected to nominate officers for the coming year. The next technical session of the Section is to be held April 13, and the subject will be Lubrication. No regular meeting is to be held in March, as the Section had not had an entertainment for a year and its members felt that they wanted one, consequently a carnival was arranged for to be held on Feb. 24.

The five scheduled papers delivered at the meeting were as follows:

Brake-Linings and Cause of Brake-Lining Wear, by John H. Watrous, of Ferodo & Asbestos, Inc.

Brakes and Brake Development, by E. M. Rondot, of the Southern California Edison Co.

Brake Adjustment, by J. G. Hulme, of Pickwick Stages

Brake Testing, by J. E. Van Sant, of the Paul G. Hoffman Co.

Brakes with BK Vacuum Attachment, by M. E. Foster, of the Electric Equipment Co.

Owing to the unavoidable absence of Mr. Van Sant, his paper was read by Mr. Weilenman, also of the Paul G. Hoffman Co. Chairman Ethelbert Favary, of the Section, introduced President Appleton and Secretary Adams, of the Automotive Council. As a distinguished visitor from the East, Dr. F. C. Stanley, chief engineer of the Raybestos Co., was called upon for remarks and took an active part in the discussion.

Brake Development Has Not Lagged

In refutation of the opinion held by many operators that brake development has not, until the last few years, progressed as fast as that of other automotive units, Mr. Rondot drew comparisons in his paper between the brakes used on the automobiles of 25 to 30 years ago and those on present cars and also between the speed of the early cars and those of today.

The first motor-vehicle brake test of record, he said, was held at Welsback Park, England, in 1902, and showed that the distance in which a vehicle could be brought to a standstill from speeds varying from 11 to 24 m.p.h. ranged from 1⅝ to 3½ times the car's length. Compared with these results, a recent brake test showed that the stopping distances for two-wheel and four-wheel-brake cars were as follows:

	Stopping Distance, Ft.	
Speed, M.P.H.	Two-Wheel Brakes	Four-Wheel Brakes
10	9	6
15	20	12
20	37	22
25	58	35

Traffic regulations adopted about 1910 necessitated better braking control, and automobile engineers did considerable experimenting on electrically operated, vacuum, hydraulic, and four-wheel brakes, according to Mr. Rondot. Although some of the first four-wheel brakes, which were installed in 1910, were improperly connected and caused a number of accidents, those of recent years have proved very efficient and are now used on all makes of cars. Hydraulically operated brakes have been perfected and they give more equalized pressure on the brake-bands, according to the speaker, than any other system in use. The system also gives a smoother-acting brake, as it obviates the friction caused by pull-rods, levers, equalizing devices, and joints.

Vacuum-controlled brake systems are now made so that they can be connected to almost any type of brake at small cost and will give a perfect braking operation without danger of failure, according to the speaker. The vacuum booster is so made that, should the booster attachment become defective, the regular brake control can still be operated.

Air brakes are the latest addition and, although rather expensive and not economical, have their place and are used with advantage on large motorcoaches, heavy trucks, and trailers.

Mr. Rondot stated that, although a great many improve-

ments have been made to brakes in the last 2 years, we still have a long way to go before they are perfect. He thinks the time is not far off when it will be possible to retard or stop the movement of a vehicle without the use of brake-drums, brake-shoes, brake-linings, and brake-rods, but that these will always be needed for emergency purposes.

Advantages of Brake-Testing Equipment

After pointing out that the road method of testing brakes is inaccurate and does not furnish any information as to what is necessary to bring the brakes to maximum efficiency, Mr. Van Sant, in his paper on brake testing which was read by Mr. Weilenman, divided the testing equipments in the market into two classes: (*a*) devices by which the wheels, after being jacked up, are individually turned against the resistance resulting from a fixed pedal pressure and the effort required, or the corresponding-brake effort, is indicated on a gage or dial, and (*b*) power-driven machines which give accurately all desired information as to maximum brake-efficiency. This second class ranges in price up to $3,000 and has been used for many years in the production line and for the final test at the car factories.

Use of a machine of the second class during 6 months by the Hoffman company has materially increased its customers' satisfaction and proved a profitable investment. A car can be run on the machine and an accurate reading of all brakes obtained in about 1 min., according to Mr. Van Sant, and results in an average saving of about 15 min. for each car tested. Time is saved also in adjusting the brakes, as accurate knowledge of the conditions eliminates guesswork and hit-or-miss adjusting. Satisfaction derived by customers has also increased the volume of brake work brought to the company, which feels that within a short time the practice of testing brakes by machine will entirely supersede road testing.

Brake-Lining Manufacture and Life

In his paper on brake-lining Mr. Watrous dealt with the subject from the points of view of the lining manufacturer and of the fleet operator. He explained that the car-stopping ability of the lining is not determined by the fabric base but by the treatment which is given to the base as a carrying-medium and stated that the initial hardness or softness of the lining does not predetermine whether the pedal pressure shall be heavy or light. The coefficient of friction, or the gripping power, is influenced wholly by the impregnating ingredients used, and the basic material usually has no more than one-half the coefficient of friction of the finished product. The coefficient of friction between the tire and road is often taken to be 0.6 as an average, and, to prevent grabbing of the brakes and locking of the wheels, the ideal coefficient of friction of brake-lining is slightly more than one-half of this figure, or theoretically about 0.35.

Folded, woven and molded types of lining were described briefly, after which Mr. Watrous told of the means employed to build coefficient of friction into the lining. Employment of a high percentage of common mineral tars as impregnating material results in carbonization at low temperatures, and when such linings are heated in an oven to about 350 deg. fahr., the impregnation bleeds out. Carbonization results in an earlier stage of glazing, with consequent loss of braking ability, the need of greater pedal pressure and, in many cases, in noisy brakes. Use of high heat-resisting pure vegetable gums gives the most uniform coefficient of friction at all braking temperatures, in Mr. Watrous' opinion, due to freedom from carbonization and chemical change.

The lining manufacturer's problem is to turn out a product of as nearly universal application as possible for use in a great variety of climatic, operating and road conditions. Introduction of four-wheel brakes has increased the burden of service on older models with two-wheel brakes operating on the same highway, and the fleet operator is faced with the problem of using to best advantage braking systems that may be grossly inadequate for present traffic conditions.

Brake-lining failures were divided by the author into two kinds: (*a*) failure to stop the vehicle properly and (*b*) failure to wear satisfactorily. The causes of each of these two classes of failure were enumerated, and the causes of noisy brakes were also listed. Rules for prolonging the life of brake-linings were given in the conclusion of the paper, as follows:

(1) Keep braking surface clean, washing off grit and abrasive material periodically and avoiding use of "dope" or surface coating
(2) Keep brake temperatures down by avoiding overloading
(3) Use proper brake-drums for severe service conditions and keep the brakes adjusted to prevent dragging
(4) Allow the lining to become thoroughly seated before using it too drastically. Do not burn-in a lining at high temperature but hammer or buff down the high spots around the rivet holes, rub a small quantity of graphite on the lining surface, and warm-up the brake only sufficiently to shape the lining to the drum

Brakes Criticized and Adjusting Advice Offered

Some criticisms that should interest car designers and production men were voiced by Mr. Hulme in commenting on brake adjusting. In the majority of cars the brake-bands are shaped so that the ends must be drawn together to make them fit the drums, he said, and this bends the band near the anchor-pin, causing it to bind. He has found in thousands of tests that, if the band is shaped so that it must be spread, the brake can be adjusted so it will not bind. In making regular adjustments, he finds that, with 1/16-in. clearance at the anchor-pin, with the bottom set just close enough to afford a clearance when the car is moving forward, and with all surplus clearance thrown to the top half of the band, the bands will work correctly under all conditions. Then see that the levers are free and well greased and that they come back against the stops, and 90 per cent of all brake troubles will cease, according to Mr. Hulme.

Not enough attention is paid to the equalizer in most modern passenger-cars, and the equalizer is allowed to pull on a slant, which throws more pressure on one wheel than on the opposite wheel, according to the speaker.

Another fault in almost all cars today is that not enough attention is paid to having the drums and bands truly circular. It would pay buyers of large numbers of vehicles to insist that the drums be tested, said Mr. Hulme. Too many pins are used in most present-day cars; by the exercise of a little forethought and care in the hook-up, the number could be reduced considerably and a number of points of wear eliminated.

Too Little Metal in Drums

Dr. Stanley stated that experiments he had made indicate that the hardness of drums is greatly affected by heat so that they score more easily; even 80-point carbon steel scores at 900 deg. fahr. Increase in carbon content, although it raises the temperature at which scoring occurs, is not a universal preventive of scoring. No steel that he could use, even up to 100-point carbon, would resist scoring at a red heat. There is a remedy for scoring, however; that is, to increase the quantity of metal in the drum. Increasing the mass to be heated lowers the maximum temperature, as heating is intermittent. Cast-iron drums used by a number of truck builders are about ¾ in. thick. Dr. Stanley said he had used these on 12-in. propeller-shaft brakes and run 70,000 miles, wearing out three sets of brake-linings, and that the drums still have a mirror-like surface. The reason is not so much because they are made

(*Continued on p.* 386)

Chronicle and Comment

Aeronautic Division Organized

THE Aeronautic Division of the Detroit Section was organized on Feb. 27 with the election of L. M. Woolson as Chairman of the Division and William C. Naylor as Chairman of the Meetings Committee. Over 300 attended the organization meeting.

Definite plans have been made for the first meeting of the Aeronautic Division during the All-American Aircraft Show, April 17 and 18. The 2-day program will include two technical sessions and an open aeronautic standardization meeting as well as an inspection trip to the Ford Airport, the Show and the aeronautic division of the Packard Motor Car Co.

The S.A.E. Handbook, 1928 Edition

THE 1928 edition of the S.A.E. HANDBOOK will be ready for distribution on or about March 28. With this edition the Handbook becomes an annual publication, instead of being issued semi-annually.

The new issue will contain the revisions and new S.A.E. Standards and Recommended Practices approved by the Standards Committee at the Annual Meeting last January, and in addition will have a thumb index to all the major sections.

Any new and revised specifications that may result from Standards Committee action at the Summer Meeting in June of this year are to be printed in a pamphlet for distribution to the members. This will be gummed so that it can be attached conveniently and permanently in the back of the Handbook, thereby making the latter current for the entire year. The specifications contained in this pamphlet will, of course, be incorporated in bound form in the 1929 S.A.E. HANDBOOK.

Report of World Motor-Transport Congress

THE complete official report of the World Motor-Transport Congress, held in London last November, and of which a news account was published in the January issue of THE JOURNAL, is now available at the office of the organizer of the Congress, Horace Wyatt, 21 Northumberland Avenue, London, W. C. 2, at a price of 7s. 6d. ($2.20).

In a letter to the Society, Mr. Wyatt writes that those who are responsible for the Congress to be held in Rome this year are asking him to act as honorary councilor to their National Committee and that he thinks he can be of most use to the committee by asking his friends to do their best to be well represented at the Rome Congress. This will start on Sept. 25 and should be very interesting. After the sessions, the delegates will have an opportunity to visit the various automotive works in Milan. The special motor roads, Italian lakes and passes over the mountains offer special attractions.

Interstate Commerce Commission Hearing

THE matter of whether Federal regulation of motor-trucks and motorcoaches is or is not desirable was formally presented before the Interstate Commerce Commission at the hearing held Feb. 10, in the City of Washington, concerning Docket No. 18,300, which relates to the report made by Attorney-Examiner Leo J. Flynn on motor-truck and motorcoach operation. A. W. Herrington, who attended the hearing, reports that the weight of the recommendations made seems to bear mainly on the following points:

(1) That some regulation of motorcoach traffic is necessary and advisable at the earliest possible date

(2) That combined regulation of motor-trucks and motorcoaches is not advisable, as each is a separate proposition and involves separate problems

(3) That any attempt to regulate motor-truck transportation at present is not desirable, and that no action should be taken along this line at present

Mr. Herrington also reports that at no time during the hearing was there detailed discussion of any sections of the report which would affect chassis design, or any feature of special interest to the Society's membership other than those mentioned herewith.

What the 1928 Roster Shows

THE 1928 Roster has been mailed to the members who have ordered copies. As heretofore, the main divisions of the Roster are the alphabetical register of members; the list of companies, with names of members associated therewith; and the geographical register of members. In addition, members connected with the Army, the Navy, United States Government Bureaus, and schools and universities are listed separately.

The Roster contains uptodate lists of the officers, committee members and representatives of the Society and of officers of the Sections for 1927-1928. Among the miscellaneous information given is a tabulation of the number of members residing in the various States of this Country. Over 5100 members are located in 11 States. In numerical order these are

Michigan	1,181
New York	1,119
Ohio	655
Illinois	453
Pennsylvania	404
Indiana	268
California	268
New Jersey	262
Massachusetts	202
Wisconsin	171
Connecticut	131
Total for 11 States	5,114

The other members residing in this Country are located in 36 other States. In addition 190 Affiliate Member Representatives and 347 Enrolled Students resident in this Country and abroad are on the rolls of the Society. Three hundred and sixty-three members have their places of business outside of this Country. The total number on the rolls of the Society as of Jan. 15, 1928, which is the date for which all of the above figures are given, is 5939.

Personal Notes of the Members

Martin Moves Plant to Baltimore

The Glenn L. Martin Co. will move from Cleveland on Jan. 1, 1929, to Baltimore, where the plant will occupy a site adjoining Baltimore's new airport. The Cleveland plant will be abandoned on June 1, 1929.

Mr. Martin's activities as an aeronautical engineer extend back to 1907, when he began to build gliders. The next year he did some pioneering work in aircraft design and also taught himself to fly. Since 1909, when he established one of the first airplane factories in this Country, he has been a prominent figure in his profession. In 1917 he organized, in Cleveland, the Glenn L. Martin Co., acting for 2 years as vice-president and general manager, for 5 years as president and general manager, and for the last 3 years as president.

Since his election to membership in 1917, Mr. Martin has been active in the work of the Society. The April, 1921, issue of THE JOURNAL contains his interesting paper, Aerial Transportation as a Business Proposition, which he presented at the 1921 Annual Meeting. During 1920 he was second vice-president of the Society, representing aviation engineering, and in 1921 he was elected councilor for the ensuing 2 years. He has several times served on the Aeronautic Division of the Standards Committee.

Mr. Martin is a member of the current Meetings Committee, and the 1928 Aeronautic Meeting will be planned and conducted under his able direction, as he is the Chairman of the Aeronautic Meeting Committee.

Collier Trophy for Lawrance

The Collier Trophy, awarded each year for the "greatest achievement in aviation in America the value of which has been demonstrated by actual use during the preceding year," has been awarded for 1927 to Charles L. Lawrance, president and general manager of the Wright Aeronautical Corporation, for his development of the engine which played so important a part in the transoceanic and other remarkable flights last year. The National Aeronautical Association, in announcing the award, commented upon Mr. Lawrance's pioneer work in the development of the air-cooled engine in America and upon his far-sightedness for the future of aviation in this Country.

Mr. Lawrance has been a member of the Society since 1905 and has taken an active part in its aeronautic affairs. He has also been a member of the Metropolitan Section for several years. Those who attended the 1922 Annual Meeting had the pleasure of hearing him present a splendid paper on Air-Cooled Engine Development, which was published in the February, 1922, issue of THE JOURNAL and later in the 1922 TRANSACTIONS.

A Saga of Machine-Tools

What the machine-tool maker's work means to the so-called average man and average woman is the theme of an instructive and entertaining article, signed by Berton Braley, that appeared in the February, 1928, issue of *Nation's Business*, under the title, The Machine Back of the Machine. A line of print, under Mr. Braley's name, tells the world that the article was written in collaboration with E. P. Blanchard, of the Bullard Machine Tool Co.

In lively style the article draws a comparison, in terms of romance, between the knight of old, symbolic of a high tradition and of a splendid ideal, and a present-day knight, the modern machine-tool workman who toils to release men from toil and serves to free men from servitude, as he labors to design, create and produce something that makes men's power greater as their toil grows less. After tracing the development of the machine-tool industry and emphasizing its importance, the authors state that the machine-tool maker is responsible for about two-thirds of our comfort, well-being and material happiness. Machine-tool improvements, it is further stated, have made it possible to produce the modern automobile at a price from one-half to one-fifth of the cost of 15 years ago, and the automobiles, it is pointed out, are better than then.

Mr. Blanchard, who has for years been connected with the Bullard company, is well qualified, both by natural ability and extensive experience, to participate in the preparation of such an article. He has already contributed to the trade press several articles on design, production, research and economics in connection with machinery and machine-tools. A paper, Integrated Production, prepared and presented by him at the Society's 1927 Production Meeting, was published in the October, 1927, issue of THE JOURNAL. Mr. Blanchard was elected to Member grade in the Society in 1927.

Mr. Blanchard's name appears on the list of those chosen to serve on the current Meetings Committee, and he is active in Production Committee work.

Brunson in Canal Zone

Capt. M. V. Brunson, Quartermaster Corps, U. S. A., sailed from New York City on Dec. 1, 1927, and is now stationed at Camp Gatun, Fort Davis, C. Z., in command of the Atlantic Motor Transport Pool at that station. The Pool has operating in it the 38th Motor Transport Company and the 19th Motor Repair Section, both organizations being a part of the Panama Canal Division Quartermaster Train. The personnel consists of 43 automobile and truck chauffeurs and 18 shop and automotive mechanics. Captain Brunson's tour in Panama will expire in November, 1930, at which time he will return to the United States. He expects to spend a month later in the current year in Peru, where he will make a study of the transportation methods employed by the Peruvian Army.

Captain Brunson has been a member of the Society since 1924.

Crawford Sails for Germany

Charles S. Crawford, who for the last 5 years has been chief engineer of the Stutz Motor Car Co. of America, Inc., has accepted a position with the General Motors Export Co. His new duties have taken him to Berlin. Prior to his connection with the Stutz company, Mr. Crawford was associated for several years with the Premier Motor Corporation and with the Cole Motor Car Co. in important engineering and executive work.

Mr. Crawford was elected to membership in the Society in 1911 and has been a member of the Indiana Section since 1914. Besides being active in committee work, he served as Councilor in 1918 and 1919.

Norman Bell's Promotion

Norman Bell, formerly assistant sales manager of the Norma-Hoffmann Bearings Corporation, is now also assistant secretary of the corporation.

An Englishman by birth and education, Mr. Bell has been associated with the automotive industry since the beginning of his professional career, his first position having been with Napier Motors, Ltd. Prior to his connection in 1917 with the Norma Co. of America, later the Norma-Hoffmann Bearings Corporation, he was for several years the motor trade representative of the Lunkenheimer Co.

(*Continued on p.* 18 *of advertising section*)

GLENN L. MARTIN

Notes and Reviews

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

AIRCRAFT

Seaplanes. By A. Guidoni. Published in *The Journal of the Royal Aeronautical Society*, January, 1928, p. 25. [A-1]

In Italy, hydrovaned floats have been consistently favored for seaplanes instead of the boats with a bottom plane surface commonly adopted in England, the United States and France. This phase of development occupies for the most part the attention of the author in his review of 15 years of naval aviation.

The earliest use of the hydrovane referred to is its employment in high-speed boats by the Italian investigators, Forlanini and Crocco. The author then discusses the theory of seaplane floats as a preliminary to recounting his own researches in the design and application of hydrovaned floats. Finally, general considerations as to the calculation of hydrovaned floats, and the area, angle of attack and form of hydrovanes for various purposes are set forth.

The Comparative Performance of an Aviation Engine at Normal and High Inlet-Air Temperatures. By Arthur W. Gardiner and Oscar W. Schey. National Advisory Committee for Aeronautics Report No. 277. Published by National Advisory Committee for Aeronautics, City of Washington. 19 pp.; 14 illustrations. [A-1]

This report presents some results obtained during an investigation to determine the effect of high inlet-air temperature on the performance of a Liberty-12 aviation engine. The purpose of this investigation was to ascertain, for normal service carbureter adjustments and a fixed ignition advance, the relation between power and temperature for the range of carbureter air temperatures that may be encountered when supercharging to sea-level pressure at altitudes of more than 20,000 ft. and without intercooling when using plain aviation gasoline and mixtures of benzol and gasoline.

The results show that, for the conditions of test, both the brake and indicated power decrease with increase in air temperature at a faster rate than is given by the theoretical assumption that power varies inversely as the square root of the absolute temperature.

A Superheat Meter or Differential Thermometer for Airships. By D. H. Strother and H. N. Eaton. Bureau of Standards Technologic Paper No. 359. Published by Bureau of Standards, City of Washington. 11 pp.; 6 illustrations. [A-1]

This paper describes a superheat meter or differential thermometer built at the Bureau of Standards for the Bureau of Aeronautics, United States Navy, to measure the difference in temperature between the confined air and lifting gas in lighter-than-air craft and the external air. The meter consists of a thermopile having one set of junctions in the gas cells and the other set in the free air.

Formulas are first developed for the lift and the effect of superheat on the lift of a rigid airship. Unusual conditions of use and some special features of construction necessitated by these conditions are given particular attention. Errors in reading due to variations in temperature of the air junctions from the standard temperature at which the instrument was calibrated and those due to the effect of temperatures on the galvanometer are discussed.

Airplane Construction and Welding. By Richard M. Mock. Reprint of paper presented before the International Acetylene Association. Published by the International Acetylene Association, New York City. 16 pp. [A-5]

After reviewing airplane construction practice, particularly with reference to welding, the author concludes that welding is now practically confined to tubular members, although the building of trusses of pressed sheeting is attracting some attention. As larger airplanes are built, and every indication shows that the time of this is not far off, welding will be used in all the major assemblies, he asserts. On smaller airplanes welding will be in still greater use, the entire structure being heat-treated after welding.

BODY

Body Designing, Upholstering and Finishing Details of Cars To Be Displayed at National Show in New York. Published in *Motor Vehicle Monthly*, January, 1928, p. 29. [B-1]

This detailed account of what was to be seen at the 1928 New York Automobile Show in the way of body design, upholstery and finish possesses interest. It is noteworthy for the discrimination with which the points emphasized are selected. The author, commenting on the extent to which refinement has been carried, analyzes carefully the separate contributions that go to make up the harmonious whole.

The fore part of the article deals with general trends and points to the exquisiteness of hardware and instrument-panel design, the popularity of saddle cushions and form-fitting backs, and the handling of color, not only for tone harmony but to help blend the body lines. Consideration of individual models occupies the major portion of the article.

Final Report of the Committee of the Chemical Section, National Safety Council, on Spray Coating. Published by the National Safety Council, Chicago. 53 pp., 9 illustrations. [B-5]

To determine the health hazards in spray coating and the methods of meeting them was the dual object of the investigation here reported. The study was conducted by a committee appointed especially for the purpose by the National Safety Council and on which this Society was represented by two members.

Conditions at 29 different plants, 7 of them automotive, were observed. Eighty-six air tests were made for benzol, 27 for lead and 33 for silica. A total of 354 physical examinations was made. The report includes the findings of

(*Continued on p. 22 of the advertising section*)

Automotive Research

"Until the headlight problem shall have been removed from the realm of speculation, where, for the most part, it now is, and quantitative measurements under road conditions are substituted therefor, supplemented by laboratory tests based on these determinations, progress which might otherwise be hoped for will not materialize."

In these words H. H. Allen[1] emphasizes the need for fundamental headlighting research, a need that is met by the investigation being carried out by him at the Bureau of Standards, and of which this paper is a progress report. The Research Committee of the Society has the project under its technical direction, and the National Automobile Chamber of Commerce is meeting its expenses. Mr. Allen's paper follows.

PROGRESS REPORT ON HEADLIGHT INVESTIGATION[2]

In the spring of 1927 work was commenced on a headlight investigation at the Bureau of Standards under the technical direction of the Research Committee of the Society of Automotive Engineers, funds being provided for this work by the National Automobile Chamber of Commerce.

The object of this investigation is to ascertain by means of road tests, supplemented by laboratory experiments, what the headlighting requirements of the driver are under various conditions and how best to fulfil these requirements under definite conditions.

The work first carried on was a series of night-driving runs made by one observer using headlight apparatus to be described hereafter in this paper. The objects of these preliminary runs were to become familiar with the use of the apparatus and to obtain qualitative data the more intelligently to lay out a tentative program. Certain purely qualitative conclusions were arrived at, formulated and discussed. In drawing conclusions, however, only such of these data will be used as may be definitely confirmed by the experimental evidence.

The preliminary experiments definitely showed that the number of variables which can be considered must, of necessity, be limited.

The physical variables involved in this problem are the horizontal spread, the vertical spread, the tilt and the intensity of the beam, besides the use of various patterns employing any combination of the above. In addition to the physical variables are the physiological and psychological differences between persons, as well as the variations in a single person from time to time. This fact may serve to indicate why a large portion of the work on this project must be of a statistical nature, and why many data are necessary. By statistical means it is hoped that the effects on visibility distance of variations of the state of mind or body of the observer, as well as the effects of numberless environmental conditions impossible to control, will be averaged out, while, at the same time, a sufficient number of various conditions may be observed and their effects noted.

FIG. 1—APPARATUS FOR OBSERVATIONS IN ABSENCE OF APPROACHING LIGHT

This Consists of Four Head-Lamps, *A*, *B*, *C* and *D*, Mounted on a Bar, Which Is in Turn Mounted on Bearings *E*. Also Fastened to the Mounting Bar Is a Tilt-Control Lever *F*, Which Can Be Locked Fast to a Quadrant, *G*. The Army Aiming Circle *H* Is Used in Part 2 of the Research. A Tree Sprayer, *I*, Marks on the Road the Point at Which the Object Becomes Distinguishably Visible

TEST METHODS DESCRIBED

In general, the method employed throughout these tests has been the observation of the distances, under various road conditions and under various environmental circumstances, at which various objects may be distinguished. The word "distinguished" is used advisedly, and the term "visibility distance" as used throughout this paper is defined as that distance at which any selected object is "distinguishably visible," in contradistinction to being merely "seen." Environmental circumstances include those which pertain to different road widths, surfaces, colors, characteristics as to smoothness or roughness, and topography; weather conditions such as fog, rain, moonlight, and other kindred factors. Obviously, some of these "environmental circumstances" may be selected at will, while others are beyond control.

By "horizontal spread" and "vertical spread" as used in this paper are meant the spreads imposed upon the original beam by the lenses used. If the lamps be in good focus, it has been determined experimentally that these nominal spreads are actually exceeded by about 2 deg., which amount should be added to the nominal spread, horizontal or vertical, or both, according to circumstances. By "zero tilt" is meant that tilt which puts the axis of the beam, not the top of the beam, horizontal. Tilt is defined as the angular deviation above or below the horizontal, tilts above being either designated as "elevation" or "plus," and tilts below as "depression" or "minus."

[1] Assistant mechanical engineer, Bureau of Standards, City of Washington.

[2] Publication approved by director of the Bureau of Standards.

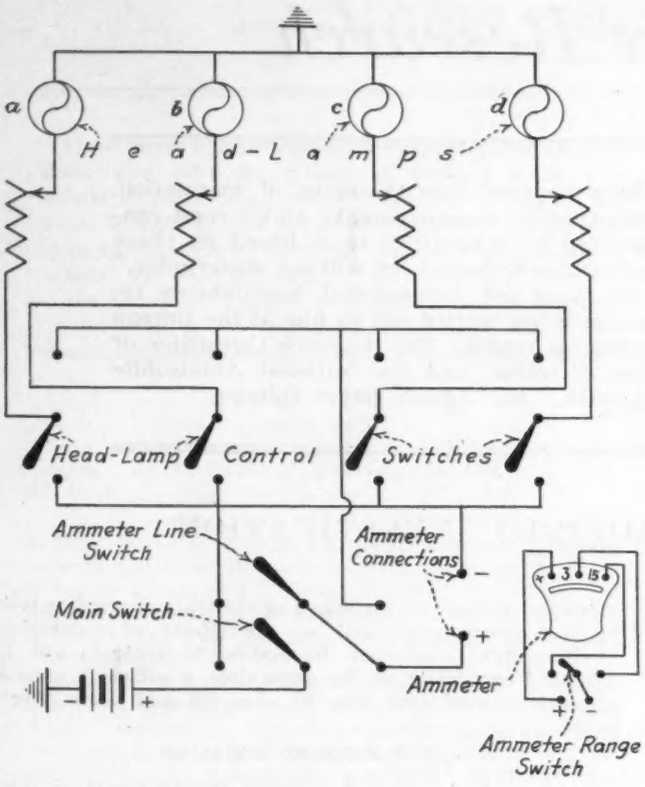


FIG. 2—WIRING DIAGRAM FOR HEAD-LAMP CONTROL SYSTEM

The Head-Lamps, *a*, *b*, *c* and *d*, Corresponding to *A*, *B*, *C* and *D* of Fig. 1, with Their Control Switches and Rheostats, Are Shown, as Well as the Ammeter and Its Wiring and Controls

A variable that is profound in its effect on visibility distance is the approach of another pair of headlights. To determine its effect on visibility, as compared with the visibility under otherwise similar circumstances, is one of the chief objects of this project.

This leads to the two principal divisions of this work, namely, Part 1, in which all of the observations are made in the absence of approaching light and as nearly as may be under the same environmental conditions, and Part 2, in which observations are made alternately with and without approaching lights, with environmental conditions as widely divergent as are likely to be met under ordinary driving conditions.

The data collected in Part 1 are sufficiently complete so that they may be reported, while Part 2 is in progress and will be reported at a future date.

PROCEDURE FOR OBSERVATIONS WITHOUT APPROACHING LIGHTS

All the runs in Part 1 were made on a concrete straightaway, essentially level and about 1500 ft. long. The roadway was marked at 50-ft. intervals commencing at zero, where objects were placed which were designed to simulate the appearance of a man, a child, or both, or other objects. The dummy of a man was painted black all over except the face and hands. Various coverings of light-colored material were also used to cover a greater or lesser area of the dummy.

The dummy or dummies were set, in every instance, in the middle of the right-of-way of an approaching car, i.e., in the middle of the right side of the road as viewed by the driver. The car with headlights on was driven toward the dummy from a distance too far away for the dummy to be seen. When the dummy became "distinguishably visible" the car was stopped, and the distance from the nearest road marker measured. Thus the visibility distance was obtained. From 5 to 15 runs were made under each condition so that an average might be arrived at which would represent the average judgment of the observer under the given conditions.

The principal object in this portion of the work was to obtain data from which the relations between visibility distance and both horizontal and vertical spread of a headlight beam, as well as between visibility distance and the angular tilt of the beam, might be determined.

Runs were made employing lenses giving nominal horizontal spreads of 2, 8, 15, 24 and 32 deg.; vertical spreads of 2, 6 and 10 deg.; and tilts from +3 (3-deg. elevation) to —3 (3-deg. depression).

The procedure was to commence with the lens of smallest horizontal spread, determine visibility distances with no vertical spread, going from +3 to —3-deg. tilt by variations of 1 deg. From 5 to 10 runs were made for each setting. Runs using successively the 2, 6 and 10-deg. nominal vertical-spread lenses were made, going through the same tilts for each of the successive combinations. The next greater horizontal spread was then used, and the whole process repeated until all combinations had been used.

Each night a series of what were designated as "standard runs" was made so that there might be a basis for comparison of the runs made on one night with those made on any other night. This consisted of a series of runs obtaining visibility distances with a nominal horizontal spread of 8 deg., 0-deg. vertical spread, and 0-deg. tilt.

Weather conditions, the presence or absence of moonlight, and other conditions likely to change from night to night were noted.

Various supplementary tests have been conducted involving other variables, the procedure being either the same or closely similar in every instance.

APPARATUS USED IN FIRST PART OF RESEARCH

The apparatus used is shown in Fig. 1 and consists of a set of four head-lamps, *A*, *B*, *C* and *D*, mounted on a bar, which in turn is mounted in bearings *E* attached to the front of the test car, the lights being controlled through a switchboard having mounted upon it a rheostat for each lamp and an ammeter suitably connected. To the same bar to which the lamps are fastened is attached a tilting bar *F*, which is capable of being locked fast to a quadrant, *G*, graduated in quarter degrees, near the operator's hand. The Army aiming circle *H* is used in Part 2 of the research. Except for the tilting device, the bearings in which the lamp bar is mounted, and other slight modications, this lamp set-up is identical with the unit developed in the course of the joint headlight research of the Illuminating Engineering Society and this Society which has been widely used

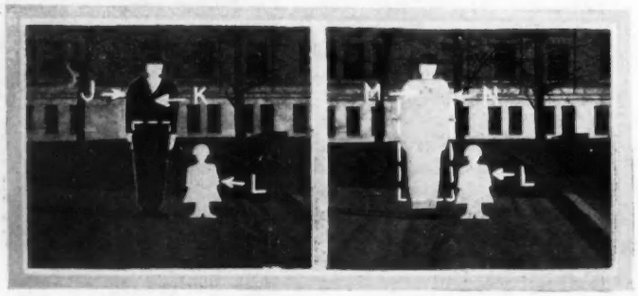


FIG. 3—TARGETS USED IN THE DETERMINATION OF VISIBILITY DISTANCE

Object *J*, at the Left, Is as Shown; *K* Is the Same Dummy but with a White Covering from the Waist up, as Included in the Dotted Lines; *L* Is the Smaller Target. Object *N*, at the Right, Differs from Object *M* by the Increase in Size Indicated by the Dotted Line

and which has been described in these pages heretofore[3].

It may be well to state, however, that the head-lamps are so constructed that either one or two lenses may be attached without disturbing the focal adjustment in any way, provision also being made for the interposition of any one of several designs of shield in front of the lens or lenses.

Two sets of lenses are included in the apparatus, each set of which is made up of four each of the following nominal spreads: 2, 3, 4, 6, 8, 10, 12, 15, 18, 21, 24, 28, 32, 36 and 40 deg. These lenses are fluted and, when the flutes are vertical, give a horizontal spread, and, when the flutes are horizontal, a vertical spread, corresponding within close limits to the markings on the lenses.

A tree-sprayer, *I*, is attached to the running-board of the car, a valve controlling the outlet from the sprayer is at the operator's foot between the brake and clutch pedals, and the outlet from the sprayer, with a plain nozzle, is directed toward the road. The sprayer may be filled with water or other liquid and when a suitable air-pressure is pumped into the tank, a mark is made upon the road upon the opening of the valve.

This device is used to obtain the distance from the point where an object first becomes distinguishably visible to the object itself when the car speed is great enough so that the stopping distance from that speed is an appreciable percentage of the visibility distance.

A wiring diagram of the head-lamp set-up is shown in Fig. 2. The results of Part 1 of the research are set forth below under five headings and the data obtained are given.

Visibility Distance versus Speed

Determination of the effect of various speeds upon visibility under identical environmental conditions was made under the following test conditions:

CONDITIONS OF TEST

Lamps	*D* and *A*
Amperes	2.5
Candlepower	21
Horizontal Spread, deg.	8
Vertical Spread, deg.	0
Tilt, deg.	0

The average maximum and minimum visibility distances obtained during 10 runs for each of four speeds were:

VISIBILITY DISTANCES AT DIFFERENT SPEEDS

Speed, m.p.h.	30-40	20-30	15	10 or Less
Average of 10 Runs, ft.	996	992	1,010	1,020
Maximum, ft.	1,045	1,015	1,020	1,040
Minimum, ft.	940	950	1,000	1,005

It is apparent from an examination of these data that speed did not have a marked effect upon visibility distance under the environments chosen. As a consequence of this, it was decided to make all runs under similar environment at speeds of 15 m.p.h. or less, as being very much easier on equipment and personnel.

[3] See THE JOURNAL, January, 1927, p. 148.

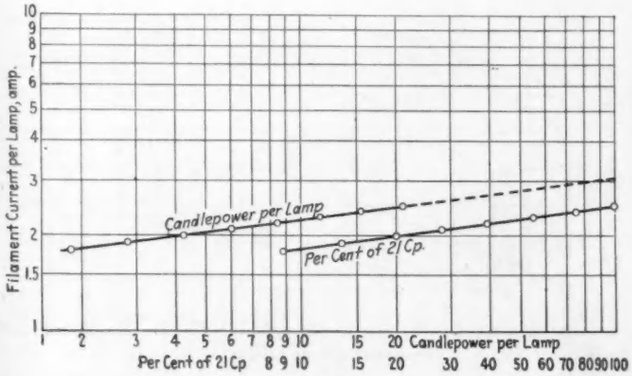


FIG. 4—FILAMENT CURRENT PER LAMP VERSUS LAMP INTENSITY EXPRESSED IN CANDLEPOWER PER LAMP AND PER CENT OF FULL-CURRENT CANDLEPOWER

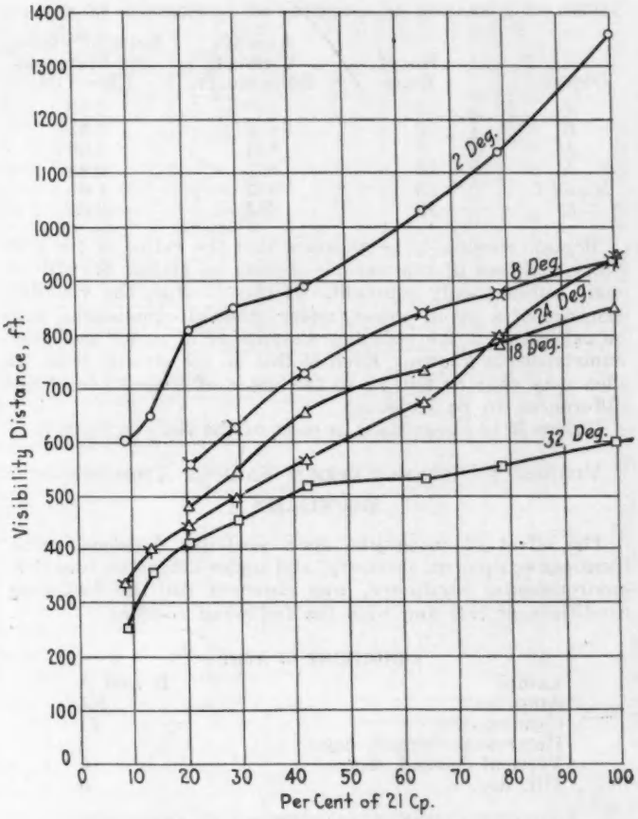


FIG. 5—RELATION BETWEEN VISIBILITY DISTANCE AND SOURCE INTENSITY EXPRESSED IN PER CENT OF 21-CP. OF THE HEAD-LAMP FOR NOMINAL SPREADS OF 2, 8, 18, 24 AND 32 DEG., WITH 0-DEG. ELEVATION AND VERTICAL SPREAD

Visibility Distance versus Size, Shape and Color of Various Objects

Comparison of the visibility distance of several objects under identical environmental conditions, the objects differing each from the others in color, size, or number, was the next step taken.

The objects used are shown in Fig. 3. At the left is Object *J*, black all over except the face and hands. Object *K* differs from Object *J* only in having a white covering from the waist upward, included by the dotted lines shown. Object *L* is the little girl, who has earned the sobriquet of Eva. At the right are shown Objects *M*, *N* and *L*, Object *N* differing from Object *M* only in being as much larger as is indicated by the dotted lines.

The following conditions of test were observed:

CONDITIONS OF TEST

Lamps	*D* and *A*
Amperes	2.5
Candlepower	21
Horizontal Spread, deg.	8
Vertical Spread, deg.	0
Tilt, deg.	0

Summarized in the following table are the results of the observations made.

VISIBILITY DISTANCE AS AFFECTED BY DIFFERENCE IN OBJECTS

Object	No. of Runs	Average Visibility Distance, ft.	Ratio of Visibility Distances (M=1.00)
J	10	477	0.58
K	10	719	0.81
M	5	884	1.00
N	14	832	0.94
N and L	5	892	1.01
L	10	604	0.68

It may reasonably be assumed that the ratios of the visibility distance of the various objects to Object M will remain substantially constant. If this is true, the visibility distance of a given object, under other circumstances, may be calculated if the visibility distance of M under those circumstances is known. Even if this be not strictly true, an idea may thus be had as to the order of magnitude of the differences to be expected.

Object M has been used in most of the tests in Part 1.

Visibility Distance versus Various Amounts of Moonlight

The effect of moonlight upon visibility distance, using identical equipment, intensity, and under otherwise identical environmental conditions, was observed for the following conditions of test and with the following results:

CONDITIONS OF TEST

Lamps	D and A
Amperes	2.5
Candlepower	21
Horizontal Spread, deg.	8
Vertical Spread, deg.	0
Tilt, deg.	0

VISIBILITY DISTANCE AS AFFECTED BY MOONLIGHT

No. of Runs	Condition	Average Visibility Distance, ft.
50	No Moonlight	930
50	Moonlight	845
	Difference	85

The difference of 85 ft. in the visibility distance as between moonlight conditions and running without moonlight is small compared with the total distance when averages are compared. However, the individual differences are much larger when the moon is very bright and the night very clear, particularly if the elevation and position of the moon be such that it shines in the driver's eyes. This factor is one which cannot be readily evaluated.

Visibility Distance versus Source Intensity

The fourth factor studied was the effect on visibility distance of varying the source intensity of the headlight from that corresponding to 1.8 to 2.5 amp., by tenths, for various horizontal spreads.

The relation between lamp intensity in candlepower and current in amperes, for a gas-filled 21-cp. lamp, is shown in Fig. 4. The curve shows a considerable dropping off in lamp intensity as the current decreases, a reduction to 72 per cent of the current necessary to give 21 cp. causing a reduction to less than 9 per cent full rated candlepower.

Fig. 5 presents a group of curves showing the relation between visibility distance and source intensity of the headlamp for nominal spreads of 2, 8, 18, 24 and 32 deg. While these curves are somewhat irregular in shape and not altogether consistent among themselves, they indicate a decreasing rate of return in visibility for increasing lamp intensities. Roughly, the visibility distances are proportional to the cube root of the intensities.

Fig. 6 presents, at the left, a group of curves showing the relation between visibility distance and nominal horizontal spread from 2 to 32 deg. for various source intensities from 2.1 to 21.0 cp. The group of curves at the right of Fig. 6 shows the relation between source intensity in candlepower and nominal horizontal spread for various visibility distances.

Figs. 5 and 6 show the same data in different aspects.

Visibility Distance versus Tilt, Horizontal Spread and Vertical Spread

The determination of the relations between visibility distance, nominal vertical spreads from 0 to 10 deg., nominal horizontal spreads from 2 to 32 deg., and headlight tilts from 3-deg. depression to 3-deg. elevation, under essentially constant conditions, constitutes the fifth portion of Part 1 of the research.

Fig. 7 presents a series of charts showing visibility distance in feet, plotted against nominal vertical spread in degrees for various headlight tilts from 3-deg. elevation to 3-deg. depression, inclusive, by increments of 1 deg. for nominal horizontal spreads of 2, 8, 15, 24 and 32 deg., respectively.

Fig. 8 incorporates a series of charts showing visibility distance in feet plotted against degrees tilt, from 3-deg.

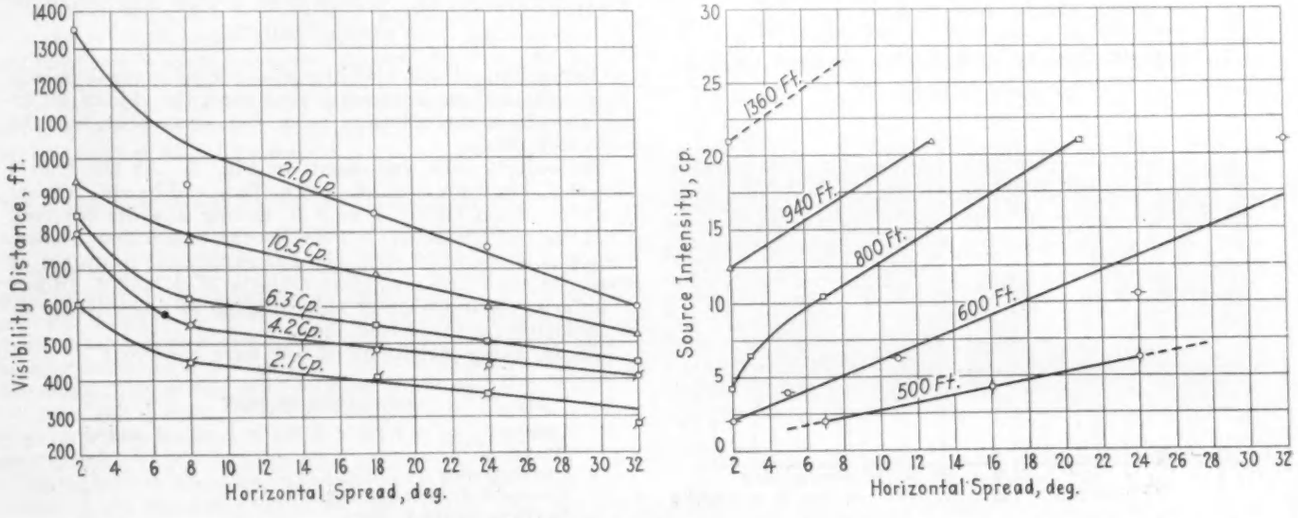


FIG. 6—EFFECTS OF HORIZONTAL SPREAD

At the Left, Visibility Distance in Feet Is Plotted against Horizontal Spread in Degrees, for Various Source Intensities; at the Right Are Shown the Source Intensities Necessary To Ensure Visibility at Certain Distances for Varying Horizontal Spreads

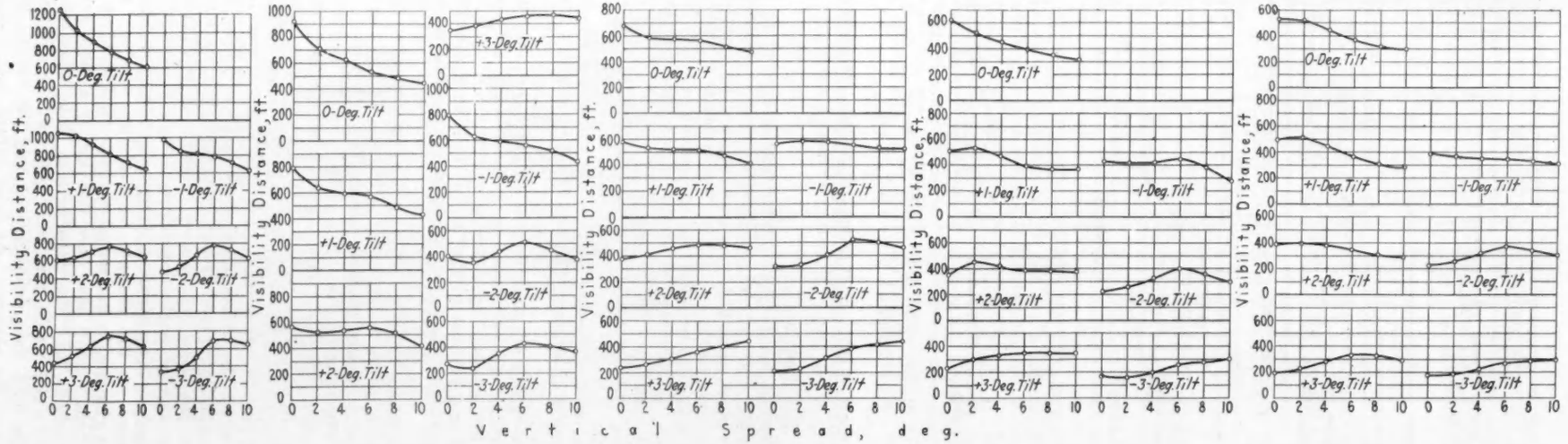


FIG. 7—CHARTS SHOWING VISIBILITY DISTANCE IN FEET, PLOTTED AGAINST NOMINAL VERTICAL SPREAD IN DEGREES FOR VARIOUS HEADLIGHT TILTS FROM 3-DEG. ELEVATION TO 3-DEG. DEPRESSION, INCLUSIVE, BY INCREMENTS OF 1 DEG., FOR NOMINAL HORIZONTAL SPREADS (FROM LEFT TO RIGHT) OF 2, 8, 15, 24 AND 32 DEG.

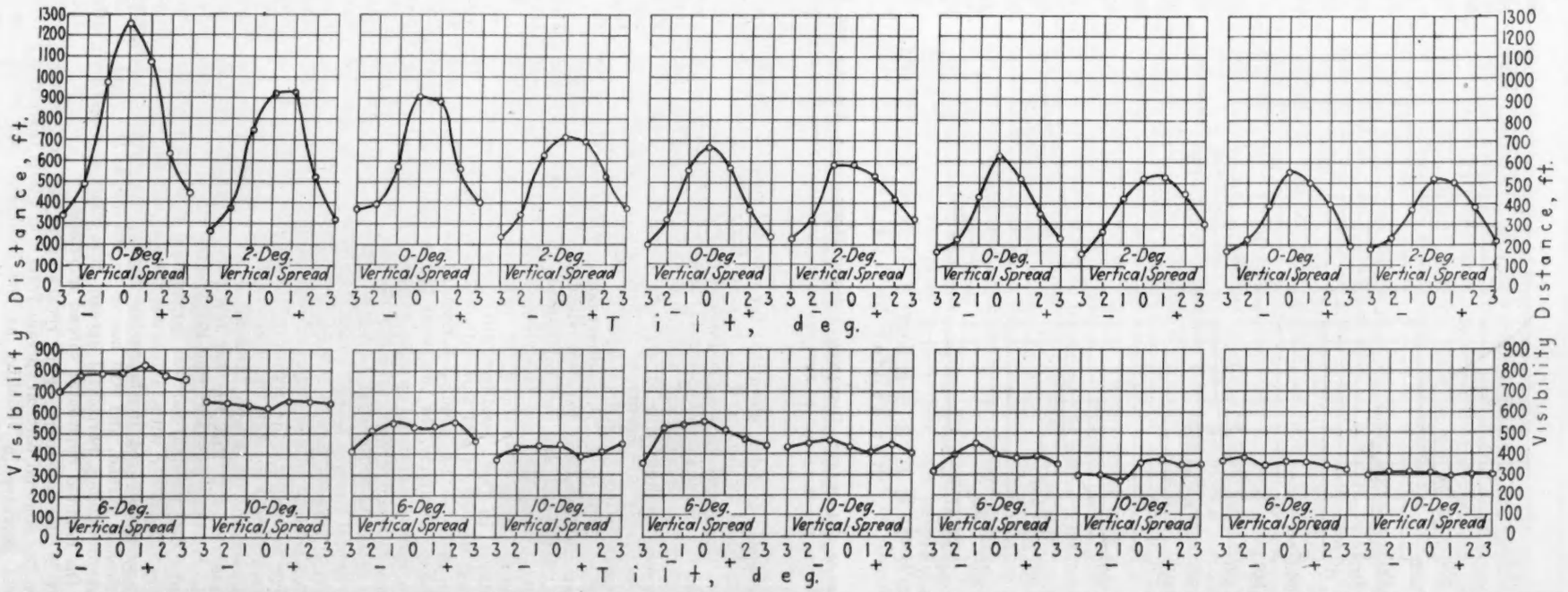


FIG. 8—CHARTS SHOWING VISIBILITY DISTANCE IN FEET PLOTTED AGAINST DEGREES TILT, FROM 3-DEG. DEPRESSION TO 3-DEG. ELEVATION, FOR NOMINAL VERTICAL SPREADS OF 0, 2, 6 AND 10 DEG., AND FOR NOMINAL HORIZONTAL SPREADS (FROM LEFT TO RIGHT) OF 2, 8, 15, 24 AND 32 DEG.

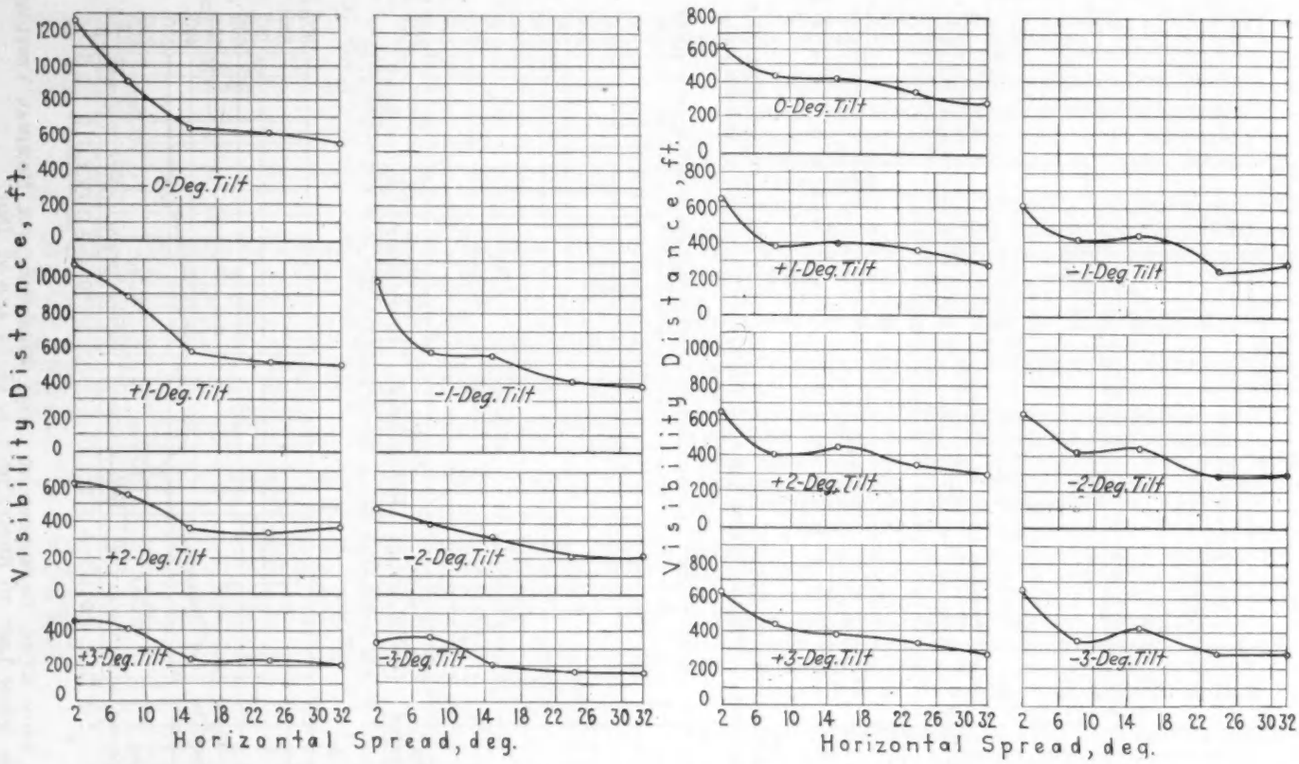


FIG. 9—VISIBILITY DISTANCE VERSUS HORIZONTAL SPREAD FOR TILTS FROM 3-DEG. ELEVATION TO 3-DEG. DEPRESSION
The Curves at the Left Show this Relationship for 0-Deg. Vertical Spread; at the Right for 10-Deg. Vertical Spread

depression to 3-deg. elevation; for nominal vertical spreads 0, 2, 6 and 10 deg.; and for nominal horizontal spreads of 2, 8, 15, 24 and 32 deg., respectively.

In Fig. 9 are given two charts showing visibility distance in feet against nominal horizontal spread in degrees for various headlight tilts from 3-deg. elevation to 3-deg. depression, by increments of 1 deg., for nominal vertical spreads between 0 and 10 deg.

Fig. 10 pictures three-dimensional graphs designed to show the relations between visibility distance, headlight tilt, horizontal and vertical spread. The upper left and right photographs are two views of the three-dimensional graphs designed to show the relations between visibility distance in feet, headlight tilt from 3-deg. elevation to 3-deg. depression and nominal vertical spread from 0 to 10 deg. inclusive, for nominal horizontal spreads of 2, 15, and 32 deg. Similarly, the two lower photographs are views of two three-dimensional graphs designed to show the relations existing between visibility distance in feet, headlight tilt from 3-deg. elevation to 3-deg. depression, and nominal horizontal spreads from 2 to 32 deg. inclusive, for nominal vertical spreads of 0 to 10 deg.

An analysis of the graphs shown in this last figure will serve to indicate the trends or tendencies of the charts shown from Figs. 7, 8 and 9 inclusive.

Observing the graph farthest to the left on the upper photographs of Fig. 10, that for 2-deg. horizontal spread, it is strikingly apparent that the greatest visibility distance is at 0-deg. nominal vertical spread, and that the visibility drops off rapidly with increasing vertical spread. This is not so pronounced in the middle figure, that for 15-deg. horizontal spread, and still less so in the one to the right, that for 32-deg. horizontal spread, this effect diminishing as the nominal horizontal spread increases.

It is also apparent, again returning to the first figure, that for nominal vertical spreads from 0 to 4 deg. there is a great decrease in visibility as the headlights are tilted either upward or downward, and the rate of change of visibility distance with respect to tilt diminishes before 3-deg. tilt in either direction; also, the decrease in visibility on the depression side is slightly greater than for a corresponding amount of elevation. It is probable that the decreased visibility distance on the depression side for the greater tilts, as compared with that for a corresponding tilt on the elevation side, is caused by the increased intensity of illumination on the road between the driver and the dummy.

The last observation applies also to the other graphs, although again it is noted that the effect of tilt is not so pronounced.

One thing which all these figures exhibit clearly is that, as the nominal vertical spread is increased, the effect of headlight tilt on visibility distance is diminished until, at 10-deg. nominal vertical spread, all of them become nearly flat, or parallel to the base line, as might readily be expected.

These relations are illustrated still more clearly in the graphs shown in the lower half of Fig. 10. The left-hand figure in both of the photographs shows the decided influence of tilt, either up or down, upon visibility distance. Examination of the right-hand figures shows clearly the reverse of this condition, namely, that the tilt affects the visibility distance scarcely at all. Examination of the upper half of Fig. 10 indicates that the nominal vertical spread at which the effects noted above occur is 6 deg. for the least horizontal spread used, and becomes slightly more indefinite in the other two figures, although occurring successively at smaller nominal vertical spreads as the horizontal spreads are increased.

The nature of the changes in visibility distance as affected by changes in horizontal spread, vertical spread, and tilt, might readily have been forecast by a method of rational analysis, and the experimental data show only those effects which would have been expected. In addition, however, the data show definitely not only the nature, but the amount of the changes. At some future date it may

be profitable to ascertain if the amounts of the changes may not also be determined by rational analysis, using the observed results as a check. These relations, when taken as a whole, constitute the backbone of the work done in Part 1 of this project.

Effect of Approaching Lights Considered

As the conditions under which automobile traveling is done at night are constantly shifting and varying, and inasmuch as the very important and much discussed factor of the effect on visibility of the lights of an approaching vehicle has not yet been touched upon, a further consideration of more complex problems lies ahead in Part 2 of this project.

The nature of the method is essentially the same in Part 2 as in Part 1, but with complications.

A description of the apparatus will precede the description of the procedure in order that the procedure may be described comprehensively without repetition.

Apparatus for Second Half of Research

The mobile apparatus includes all that described previously. To the equipment on the car shown in the photograph in Fig. 1 is added a portable photometer, *O*, a grademeter, *P*, graduated to read per cent grade from level to plus or minus 10 per cent; and a 3¼ x 5½-in. camera, *Q*. Either the camera or the aiming circle, which in this work is used as a stadimeter to obtain distances of from 20 to 200 m. (65.62 to 656.17 ft.) when sighted on a 2-m. (6.56-ft.) object, may be mounted on the windshield column as shown in the upper photographs of Fig. 11. The upper right photograph also shows the operator in the position normally occupied when taking a photometric reading.

To the rolling-stock has been added the car shown in the lower photographs of Fig. 11. This car will be designated as Car *R*, and the one originally used, Car *S*, for purposes of identification.

Car *R* is equipped with a four-head-lamp set-up identical with that on Car *S*. This equipment, however, is on the rear of the car instead of at the front, as is the case with Car *S*. Because of this, the headlight-tilting device, *V*, is carried through the rear window, as shown at the lower right in Fig. 11, to a locking device divided by quarter degrees from +6 deg. (6-deg. elevation) to —4 deg. (4-deg. depression). The device can be operated from the driver's seat. On the right rear of Car *R* is mounted a vertical rod upon which are attached two 2-cp. lamps, *U*, which are 2 m. (6.56 ft.) apart (see lower left view, Fig. 11). These lamps are controlled from within the car by a switch. Car *R* also is equipped with a grade-meter.

The dummies used in Part 1 are dispensed with and, instead, a rectangular target, *T*, is attached to the right front door of Car *R*. This target may be either folded flat against the car and secured, or extended to the right into the roadway, as shown in the lower left view, Fig. 11, and in Fig. 12. It has been found experimentally that this target is distinguished about 90 to 95 per cent as readily as Object *M* used in Part 1.

The switchboard and control system for the head-lamp set-up is exactly the same in both cars, both electrically and mechanically, except that a rolling screen, *W* (see Fig. 12), must be provided to cover the head-lamps on Car *R*

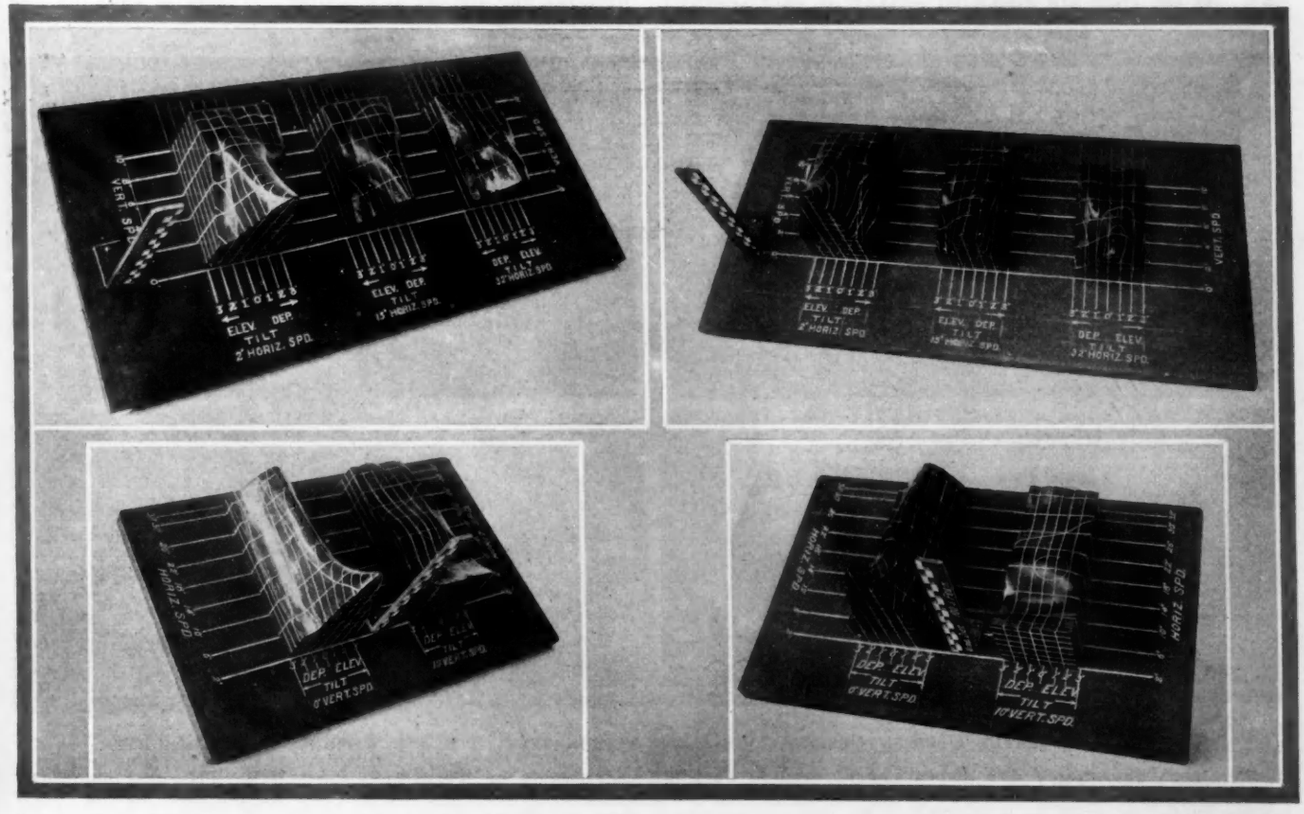


Fig. 10—Three-Dimensional Graphs Illustrating Some Results of Part 1 of Headlight Research

The Upper Right and Left Photographs Show Views of the Graphs Designed To Show the Relations between Visibility Distance in Feet, Headlight Tilts from 3-Deg. Elevation to 3-Deg. Depression, and Nominal Vertical Spreads from 0 and 10 Deg. Inclusive for Nominal Horizontal Spreads of 2, 15, and 32 Deg. The Graph Pictured in Different Views, Lower Left and Right, Show the Same Relationship for Nominal Horizontal Spreads from 2 to 32 Deg., Inclusive, for Nominal Vertical Spreads of 0 and 10 Deg. These Graphs Indicate the Tendencies of the Charts in Figs. 7, 8 and 9 and Summarize a Large Portion of the Research to Date

when they are not in use. A hole in this curtain exposes a red lamp in lieu of a tail-lamp.

A fair-sized and brilliantly lighted stop-light is an essential part of the equipment of Car *R*, and it is attached to the front end of the car, where it may be plainly seen. The reasons will appear hereafter.

Procedure in Considering Effect of Oncoming Lights

Car *R* precedes Car *S* along a selected roadway to the point chosen for the first observation. It is stopped to the left of the center of the roadway, the driving lights are extinguished, the front stop-light is turned on, and the target is swung out at right angles to the car, into the right of the center of the roadway. The operator of Car *S* is unaware of the place at which Car *R* has stopped, and proceeds toward it until the target is "distinguishably visible." Car *S* then stops, signals to Car *R* with an appropriate and predetermined light signal, the range lights on the vertical rod on Car *R* are thrown on and a measurement of the distance between the two cars is taken and noted by means of the aiming circle mounted on Car *S*. The range lights on Car *R* are then extinguished upon signal from Car *S*, the covering curtain over the head-lamps on Car *R* is rolled up and the lights turned on, Car *R* remaining in place. Car *S* again proceeds toward Car *R* until the target is again "distinguishably visible," and that distance is similarly measured and noted. In this manner alternate runs are made with and without approaching headlights, Car *R* simulating an approaching vehicle, and obviating the necessity for a complete "turn-around" for every observation, which would be necessary with a conventionally equipped car. As the runs are numbered serially by each operator

Fig. 12—Car *R* in Test Position

In the Picture at the Left the Head-Lamp Curtain, *W*, Is Down To Darken the Lights, at the Right It Is Rolled Up so That the Effect of Oncoming Lights Is Simulated. The Spread-Demand Target Is Shown at *X*

to correspond, a complete record is obtained in which all the odd-numbered runs are those without approaching headlights, while all the even-numbered runs are those with approaching headlights.

The data concerning those variables controllable by the operators are noted by each operator before the commencement of a run and through the run when change is necessary.

Both operators note the horizontal spread, the vertical spread, the current and the candlepower, the nature and character of the shield used, if any, and the amount of the tilt, for each head-lamp.

The operator of Car *R* notes, in addition, the condition of the weather as to rain, fog and clouds, as well as the presence and amount of moonlight, if there be any.

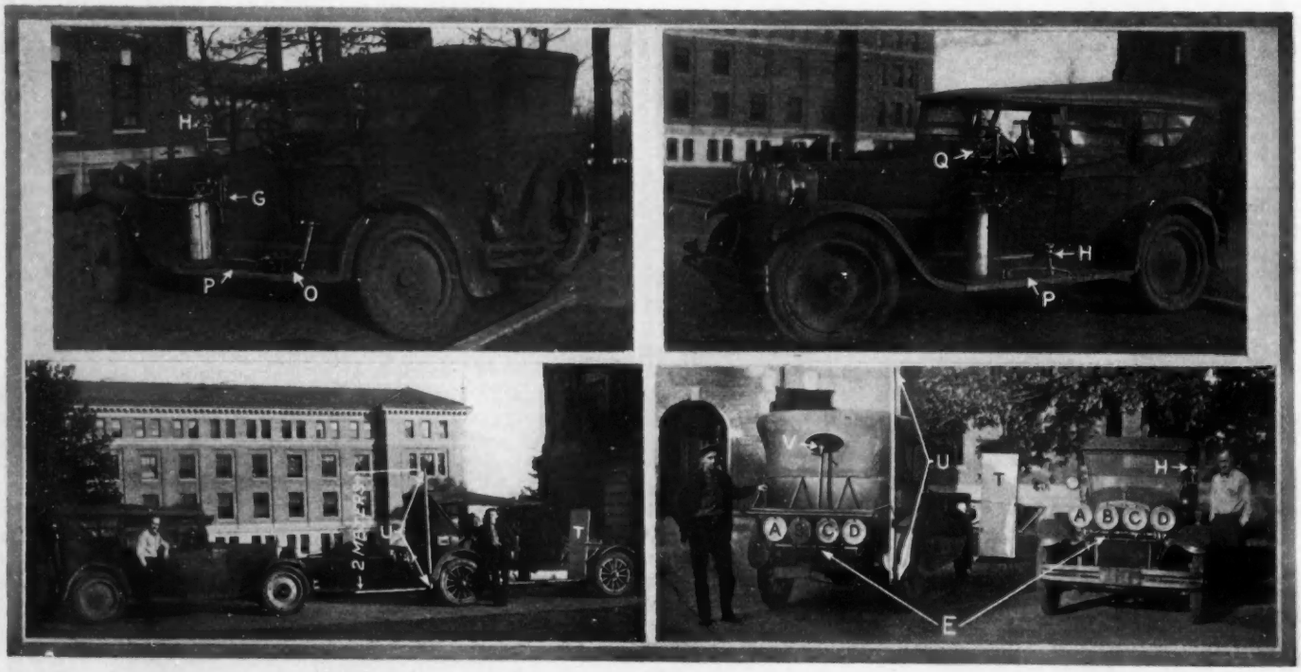


Fig. 11—Apparatus Used in Observations Made Alternately with and without Passing Lights

In the Upper Photographs Are Shown Car *S*, Used in Part 1, with Additional Equipment Necessitated for Part 2; the Army Aiming Circle, *H*, Used as a Stadimeter To Obtain Distances, the Grade-Meter, *P*, and the Photometer, *O*. A Clear View Is also Shown of Locking Device *G*. The Camera Is Mounted at *Q* in the Photograph at the Upper Right, Where the Driver Is in the Position Occupied When Photometer Readings Are Taken. The Lower Views Include Car *R*, Added for Part 2 of the Research, Equipped with a Four-Head-Lamp Set-Up Identical with That on Car *S*, but Mounted on the Rear. At the Left the Cars Are in the Position Occupied in the Procedure but Closer Together than Is the Case in the Actual Experimental Work. Here Are Shown the Rectangular Target *T*, Which Replaces the Dummies of Part 1, and the Aiming Circle Target-Lights, *U*, Which Are Controlled from Within the Car. In the Picture at the Right May Be Clearly Seen the Rod *V* for Tilting the Rear Headlights, Which Is Operated from the Driver's Seat, the Aiming Circle *H*, the Two Sets of Head-Lamps *A*, *B*, *C* and *D*, and Other Objects Which Are Also Shown in the Other Photographs of This Illustration

Both operators note and record any unusual circumstances which seem likely to affect the results.

In Fig. 13 are exhibits of typical data sheets.

When engaged in conducting a run, the operator of Car *R* also notes and records the nature, width and character, as well as the color, of the roadway upon which he is traveling, the amount and direction of the grade at the point where stops for observations are made, and any circumstances such as bumps or hollows between the two cars, whether either one or the other is on the crest of a hill or at the foot of one; notes and records whether his car is on a curve, and the direction of it, and records under "remarks" any circumstance peculiar to that particular run number. He also notes, for each even-numbered run, whether, in his judgment, the axis of the beam of his lights appear to be over or under that of the other.

The operator of Car *S*, in addition to noting the visibility distance, the direction and amount of the grade, and the curvature upon which the car stops, for all runs, observes and records his judgment as to the visibility of the right-hand shoulder of the road, that is, whether it be good, fair, or poor, and obtains a reading with the photometer of the apparent beam-intensity of the light at the point where the driver's eye would be while driving (see upper right view, Fig. 11) for all even runs.

Program for Second Part of Headlight Research

Roads.—Roads will be selected which are typical of every kind likely to be commonly traveled. Particular attention will be given to include roads upon which may be found curves, sharp turns, and hills, as well as straightaways

Lenses.—In general, a similar procedure is contemplated with respect to the employment of different combinations as that employed in Part 1, although it is likely that as wide a range of vertical spreads may be found to be unnecessary.

Tilts.—It is contemplated that tilts from 0 to 3 deg. depression will be employed, the same tilt being used on both cars in every instance

Intensities.—The effect of intensity upon visibility will be studied; using intensities of various relative amounts on the two cars. It is planned to increase the range of intensities to include those considerably above 21 cp.

Headlight Arrangements.—It is planned to use various unsymmetrical headlight arrangements on both cars

Beam Patterns.—Eventually, it is planned to obtain photographs of representative beam patterns upon a standard screen, for purposes of correlating the results obtained. These patterns may be obtained by using different shields as well as different lenses

Determination of Spread Demand

Considerable data have been accumulated, as well as considerable information obtained therefrom. An intelligent and comprehensive exposition of the results cannot be made, however, until after a sufficiently great volume of these data have been collected covering the entire field to be surveyed. Conclusions based upon a portion of the work would be immature.

Part 2 (*a*) includes a determination by photographic

(*Continued on p.* 384)

SHEET NO. 49 R — DATE 12/8/27 — OBSERVER M. H. deB

LAMPS	D	C	B	A
AMPERES	2.5	—	—	2.5
HORIZONTAL SPREAD	10°	—	—	10°
VERTICAL SPREAD	—	—	—	—
SHIELD	—	—	—	—
CANDLEPOWER	21	—	—	21
TILT	—	ELEVATED	—	DEPRESSED

WEATHER	CLEAR	RAIN	CLOUDY	FOG
	✓			

MOON	NO	1/4 TO 1/2	1/2 TO 3/4	3/4 TO FULL	FULL
					✓

REMARKS

ROADWAY							GRADE		CURVE		LIGHTS		
RUN NO.	CONCRETE	BLACK	DIRT	DRY	WET	WIDTH	UP	DOWN	RIGHT	LEFT	OVER	UNDER	REMARKS
961		✓		✓		15		6	—				
2		✓		✓		✓		6	—		—		
3		✓		✓		✓	2.5		—				
4		✓		✓		✓	2.5		—		—		
5		✓		✓		✓	9		—				
6		✓		✓		✓	9		—		✓		
7		✓		✓		✓	7.5			✓			
8		✓		✓		✓	7.5			✓	✓		SLIGHT CURVE
9		✓		✓		✓		8	✓				
970		✓		✓		✓		8	✓			✓	
1		✓		✓		✓	2		—				
2		✓		✓		✓	2		—		—		
3		✓		✓		✓		8	—				
4		✓		✓		✓		8	—			✓	
5		✓		✓		✓	8		—				
6		✓		✓		✓	8		—		✓		
7		✓		✓		✓	—		—				
8		✓		✓		✓	—		—		✓		
9		✓		✓		✓	1		✓				SHARP CURVE
980		✓		✓		✓	1		✓		—		

SHEET NO. 49 S — DATE 12/8/27 — OBSERVER H. H. A.

LAMPS	D	C	B	A
AMPERES	2.5	—	—	2.5
HORIZONTAL SPREAD	10°	—	—	10°
VERTICAL SPREAD	—	—	—	—
SHIELD	—	—	—	—
CANDLEPOWER	21	—	—	21
TILT	ELEVATED 0° DEPRESSED			

Filter 5.4 and 47.6 on comparison side of photometer

RUN NO.	DISTANCE METERS	DISTANCE FT.	LIGHTS OVER	LIGHTS UNDER	ROADWAY GRADE UP	ROADWAY GRADE DOWN	ROADWAY CURVE RIGHT	ROADWAY CURVE LEFT	SHOULDER VISIBILITY GOOD	SHOULDER VISIBILITY FAIR	SHOULDER VISIBILITY POOR	PHOTOMETER READING	PHOTOMETER APPARENT BEAM INTENSITY CANDLES	REMARKS
961		262	✓		—		—							ON CREST
2		71	—			5.0	—				✓	12.5	421	
3		328	—		—		✓							
4		101		✓	1.5		—				✓	15.0	1010	
5		212		✓	6.5		—							
6		122		✓	6.0		—		✓			4.9	477	
7		228	✓		7.0		—							
8		101	—		3.5		—		✓			3.6	242	
9		119	—			6.0	✓							
970		119	—			6.0	—		✓			< 1	< 940	SHARP CURVE
1		437	—		—		—							
2		109		✓	—		—				✓	14.0	1105	
3		226	✓		1.0		—							ON CREST
4		91	✓			6.0	—				✓	21.0	1150	
5		182		✓	2.0		—							
6		129		✓	4.0		—		✓			2.8	310	
7		219	✓		6.0		—							"R" ON CREST
8		94	✓		—		—				✓	18.5	1095	
9		82	—		—		✓							
980		73	—		—		✓		✓			1.3	457	SHARP CURVE

FIG. 13—TYPICAL DATA SHEETS; THAT TO THE LEFT OF THE PRECEDING AND THAT TO THE RIGHT OF THE FOLLOWING CAR

Operation and Maintenance

Activities of the Operation and Maintenance Committee and its Subcommittees since their formation were reported and discussed at the session of the Transportation Meeting held in Chicago on the afternoon of Tuesday, Oct. 25, 1927. The report of F. J. Scarr, chairman of the Subcommittee on Motor-Vehicle Regulation, was printed in the December, 1927, issue of THE JOURNAL on p. 646. The discussion which followed this report is printed herewith.

In the January, 1928, issue of THE JOURNAL, the report of the West Coast Subcommittee on Operation and Maintenance, presented by E. C. Wood, chairman of the Subcommittee, was printed in full, beginning on p. 27. The discussion which followed the presentation of the report is also printed herewith.

Discussion of Report on Motor-Vehicle Regulation

F. J. SCARR[1]:—The Subcommittee on Regulations has passed through a difficult period of getting started, due perhaps to the selection of the name, which included the word "regulation." There was some serious question as to the advisability of an engineering society interesting itself in matters which could in any way be described as "legislation." Those differences have fortunately all been straightened out and everyone with whom the chairman of that subcommittee has discussed the matter has indicated his full approval of the work as planned, and as stated in this first report, which is perhaps best described as a policy report rather than one of actual progress.

We have no ambition either to promote actively or to oppose prospective legislation, or to perform either of those functions in connection with existing legislation. It is our thought that a great amount of engineering data exists that should be collected and made available to those who are directly interested in the matter of legislation or regulation. Those most interested in highway-transportation regulation, that is, the motorcoach and the motor-truck operators, should have it also. In the last several years the Society has augmented its membership greatly in both of these classes, and the subcommittee's work therefore has been on behalf of those Society members.

We have studied the Uniform Motor-Vehicle Code carefully, we have prepared for the information of the committee members our analysis of that code and other work that has progressed along the line of regulation, and we are prepared now to act in an advisory capacity on many of the subjects involved in those efforts. As stated, it is our thought that our work should be completely in an advisory capacity and that we should function actively only as requested by those directly interested in the passage or repeal of particular legislation. It is our hope that when we gather additional information we may be called in, from time to time, by legislative committees simply as an impartial adviser in an engineering way on the problems with which they are faced.

CHAIRMAN R. E. PLIMPTON[2]:—Will Mr. Williams please outline the Uniform Motor-Vehicle Code, sometimes called the Hoover Code? We would like more information regarding the progress of the introduction of the code.

SIDNEY J. WILLIAMS[3]:—Secretary Hoover called together about 3 years ago the National Conference on Street and Highway Safety, sometimes called more briefly the Hoover Conference. The National Safety Council, with which I am connected, was one of three organizations which suggested that action to Secretary Hoover for the purpose of getting a greater amount of joint action on the very pressing problem of highway traffic, particularly from the standpoint of safety. That first conference divided itself into eight committees which submitted some valuable reports on various phases of the street and highway safety-problem. One of those reports was on the subject of the motor-vehicle itself. Members of this Society had a great part in framing that report and I think the report has exercised important influence on some developments in motor-vehicle design since that time. This first conference adopted, from its committee reports, a number of excellent general principles that were believed to apply to the highway-traffic problem.

After the first conference there was a general feeling that something more was needed and that there was need also for agreement, if possible, on a uniform State motor-vehicle law. The reason was that, although it was found possible to get various people to agree, for example, that there ought to be State laws licensing motor-vehicle operators, which laws already exist in practically all Eastern States, when an attempt was made to pass some of those laws in other States we found much disagreement as to what sort of a license law should be passed. So we said:

> Let us agree that when we say "drivers should be licensed," we mean that they should be licensed according to some specified law.

There was no intention that there must be an agreement on every word of the specified law, but we realized that we would get nowhere until we reached a definite agreement on what we were talking about. Therefore, following the first conference which was held 2½ years ago, an additional committee was formed to develop a model State motor-vehicle law. The purpose of that law was to be two-fold; the first object was safety and the second, uniformity.

INDUSTRY REPRESENTED ON HOOVER COMMITTEE

At that time another very influential body, the National Conference of Commissioners on Uniform State Laws, was interested in the same subject. It seems that for many years every State had officially delegated two or three lawyers, frequently men who were members of the State legislature, to take part in a National conference to work for uniformity on all sorts of legislation. They developed the present uniform bill of lading and other measures that are uniform among the States. This group was much interested in standardizing, or coordinating, the State motor-vehicle laws. Since they had an important official standing in their respective States, it seemed sensible to join forces with them. Therefore this Uniform Motor-Vehicle

[1] M.S.A.E.—President, Scarr Transportation Service, New York City.

[2] M.S.A.E.—Associate editor, *Bus Transportation*, Chicago.

[3] Director of public safety division, National Safety Council, Chicago.

Code was made a joint project between the Hoover Conference on Street and Highway Safety and the National Conference of Commissioners on Uniform State Laws.

The actual committee that developed it was composed of 33 men. The automotive industry, speaking very broadly, was represented by David Beecroft, of the Class Journal Co.; David Fenner, of the International Motor Co., and Mr. Laird, of the Pittsburgh Yellow Cab Co. Three other men represented various automobile clubs. Public officials and various others interested in the subject were also members of the committee and, in the work on the code, many hundreds of other people were in consultation. For example, the automobile-lighting interests were in extensive consultation on the specific subject of headlighting requirements.

Scope of the Motor-Vehicle Laws

On the question whether it is desirable to have a detailed exactly uniform model code or we should be content to agree on general principles, we ran into difficulties when we had only general principles and no exact code. Everyone who has anything to do with standardization starts out with the idea that the standards need to be simple and general. It is easy to say that, but actually they need to be specific to a large extent or else the work means nothing. But it is not at all the thought, so far as I know, that every State in this Union is expected to adopt identical motor-vehicle legislation. I have never cherished any such foolish idea. At present, the National Safety Council is preparing an abstract of the Motor-Vehicle Code that will set forth its essential principles, specifying the things on which we need exact uniformity and the things on which we need nothing more than substantial uniformity. For example, we need uniformity on the right-of-way rule, which presents a very complicated problem. If it can be worked out in the best legal language it will be highly desirable to have that rule uniform in the different States.

I have been asked to what extent criticism of this code from the Society and from other representative groups is welcome. Insofar as I can answer, criticism is most welcome. We are far from thinking that the code as it now stands is perfect, or that any State must adopt it just as it is. Thousands of copies were sent throughout the Country before it was passed upon to get criticism in advance, but constructive criticism is just as welcome now as it was at any earlier stage.

Classification of Code Criticism

Criticism can be divided into three kinds. First, there are criticisms of details. For example, as one reads a particular paragraph of the code he may say:

> If that were applied to my particular situation of operating a motorcoach line in Kansas, it would work so-and-so. It would have a bad effect.

That sort of criticism is valuable. Probably the committee never thought of that particular contingency. So, if the members of the Society and others can agree and will collect criticism of that sort regarding details in which the code does not work the way it should work, such criticism is most welcome.

Other criticisms bear on controversial points that have been thoroughly discussed by the committee. For example, there is some difference of opinion throughout this Country as to whether the drivers of private passenger-cars should be put through an examination before licensing and then should be licensed as they are in the Eastern States, or whether the licensing should be handled as it in the Middle West. That is a controversial question. The committee debated it thoroughly and decided to recommend the practice of the Eastern States. If this Society as a whole should feel that this position is wrong, we would all like to know it. Both of the foregoing kinds of criticism are constructive and are welcome.

Unfortunately, there is a third kind of criticism which can be called captious. It is foolish criticism. For example, one of the letters which criticized this code said that, because the code required a towed vehicle to carry some sort of red flag on the tow-rope to mark it and warn drivers from running into the rope, it should also require a red light on the tow-rope at night. Such criticism seems to be inspired more by the idea of fault-finding than by a desire to help the cause of uniformity and safety in this Country.

Specific Criticisms of the Code

One criticism was that the code should be more simple and should omit various details. Among other things, it was suggested that the code should omit the specific regulations on how to make a right or left turn at intersections; that it should leave out the section referring to giving the pedestrian the right-of-way at cross-walks and giving the vehicle the right-of-way between cross-walks; that it should leave out the prohibition of driving through a safety zone; and that it should omit a dozen or more other provisions and substitute for all of them the general requirement that nobody shall drive unsafely. I think the National Committee cannot agree with that criticism.

Another criticism was that it is foolish to require carrying the registration card in the vehicle or on the person of the operator. Another was from a man on the Pacific Coast to the effect that the registration card should always be carried in the vehicle and that this had been found an eminently practical and desirable thing to do in California where the requirement is now a State law. In other words, those criticisms from members of the Operation and Maintenance Committee were diametrically opposite.

Criticism in another instance was that the court should have authority to revoke licenses, or that the licenses should be revoked by the State motor-vehicle commissioner, to whom the court shall make recommendations to that effect. That is a debatable point. The opinion of the National Committee was that it would be undesirable to give every little court in the Country arbitrary authority to revoke licenses.

There was criticism of the provision of the code on clearance lamps. I know little about the exact specifications that are desirable for clearance lamps, but if, after considering the subject, it is felt that the code is wrong, by all means let us have a substitute provision on that subject.

Debatable Question of Left Turns

Another member of the Operation and Maintenance Committee raised a question about the rule on making turns, saying that it would be difficult for many large vehicles, such as motorcoaches, to make a left turn as the section now specifies. The two answers to that criticism are, first, that the code now provides that local authorities may, when they desire, put buttons or lines, or both, on an intersection so as to have left turns made in any way they like; in other words, they can use the four-button method in designating left turns at intersections. Second, in my opinion a question exists as to the extent to which very long vehicles having a long turning-radius should make left turns in congested-traffic conditions.

When the people in Chicago set out to improve traffic conditions in the loop district, the first thing done was to bring about a rerouting of street-cars so as to eliminate all but one or two left turns of street-cars in that district, because the making of left turns with the long street-cars constituted a serious obstruction to traffic. They eliminated practically all the left turns and greatly cut down the number of right turns of street-cars in the same district. They also rerouted the motorcoaches in the loop district. It seems to be desirable for all motorcoach operators to lay out their routes through congested traffic in such a way as to eliminate, if possible, the making of left turns when the vehicles are built so that they cannot make a left turn in the way prescribed for ordinary vehicles. That is a debatable subject and something on which a recommendation from this group of operators would be much in order.

In closing, I feel at some disadvantage because I have

not been given any definite criticism, by the Operation and Maintenance Committee as a body, to answer. I have been given several unrelated opinions of different members and I have referred to a few of them, but I think it would be very desirable if this committee, and possibly the entire Society, if that is practicable, would give careful scrutiny to the Uniform Motor-Vehicle Code, arrive at criticisms which represent the whole committee or the whole Society, and then let us have them. Another request is that the Society cooperate with the National Safety Council, which is becoming deeply interested in the engineering phases of the subject.

Subjects for the Committee To Consider

Chairman Plimpton:—We did not offer definite criticism of the code to Mr. Williams because the committee has not formed a definite opinion. We have kept clear of all matters relating to design and construction. In studying the subject, the Subcommittee considered matters of interest in the field of operation and maintenance, the reason being that the Motorcoach Division of the Society had already gone into the field of construction. Since we had the precedent of having the Society act in an advisory capacity, we went ahead and made a very brief report. If, in the opinion of the members of the Society, it is considered worthwhile to follow the matter up, we can do so. There are two different things to consider: First, whether it is advisable for the Committee, through its subcommittees, to go into the subject at all; second, the specific points that have been brought out in the report.

M. C. Horine[4]:—This discussion brings to a focus the fact that the most important subcommittee of the Operation and Maintenance Committee is that on nomenclature. We were going against that in connection with our so-called Subcommittee on Accounting which, we discovered recently in Cleveland, was not on "accounting" but was on "cost finding." Now we find that the committee which was called a Subcommittee on Regulations is not a regulations subcommittee but a restrictions or anti-restrictions subcommittee. I think that is the chief value we have obtained from this debate. In an informal way the Subcommittee on Nomenclature should take under consideration the titles of the subcommittees of our main committee.

A. J. Scaife[5]:—We are on dangerous territory when we go into this matter of legislation. Other bodies, such as the National Automobile Chamber of Commerce and the American Automobile Association, are capable of handling this subject and we have in our own Society committees composed of engineers of the organizations that are at present cooperating with the State authorities which have, for the last 3 years, been covering these matters of design and the like with reference to legislation. If we go into all these things, we shall be doing ourselves good; but we ought to proceed very cautiously as an engineering society, because many other organizations exist which are well qualified to do the work.

Discussion of West Coast Operation and Maintenance

A. J. Scaife[5]:—What length of life can we expect from a unit? How long can we operate it profitably?

E. C. Wood[6]:—Table 1 results from replies to a questionnaire sent out to fleet operators in the Middle West and on the Pacific Coast regarding how long it is profitable to operate passenger-cars before replacing them.

TABLE 1—LIFE OF A PASSENGER CAR

In Miles of Service		In Years of Service before Replacement			
Operators Reporting, No.	Miles	Operators Reporting, No.	Years	Operators Reporting, No.	Years
2	5,000-10,000	7	1	9	4
18	10,000-20,000	3	1½	2	4½
66	20,000-30,000	52	2	6	5
68	40,000-50,000	2	2–3	3	7
41	50,000-60,000	19	3	1	9
7	60,000-70,000	5	3–4	165	No record
20	70,000-80,000				

The men who were responsible for assembling the West Coast Subcommittee report are: P. Ducker, of the Southern California Edison Co.; W. H. Fairbanks, of the Southern California Telephone Co.; E. Favary, of the Moreland Motor Truck Co.; F. D. Howell, of the Motor Transit Co.; E. Power, of the Union Oil Co. of California, all of Los Angeles; W. S. Penfield, of the Associated Oil Co., and S. B. Shaw, of the Pacific Gas & Electric Co., both of San Francisco; H. Drake, of the Portland Gas & Coke Co., Portland, Ore.; and G. R. Gwynne, of the Continental Oil Co., Denver.

Chairman R. E. Plimpton[7]:—Mr. Winchester will discuss this report first. He has been serving as chairman of the Subcommittee on Mechanical Information Sheets.

J. F. Winchester[8]:—Although we have held no meeting of this subcommittee, we have been very active in other affairs of the Society. I think the benefit of the mechanical information sheets has been brought out by Mr. Wood's report. I have used them for many years. If we operate vehicles over a period of 10 to 12 years without replacing them, we shall have some orphan vehicles on our hands eventually. If we come in contact with any service organization, good or poor, we know then how beneficial an original record of this kind is in keeping the manufacturer in touch with conditions and furnishing him with proper service information as to what our actual necessities are.

During the last several months I have gathered a number of these sheets of different types with the intention of sending them to the National Automobile Chamber of Commerce and to different automobile manufacturers to get their opinions as to what can be done along this particular line. I think it is a very simple problem to solve, and have no extended comments to make in connection with its details. The majority of the troubles encountered in the West are being encountered in the East, but it might be interesting and well worthwhile to send out a questionnaire to the operators in the East to determine how they would classify their mechanical difficulties from a percentage standpoint. I would particularly like to have questionnaires sent to some of the gasoline-electric-vehicle operators and data obtained on that type of equipment, of which I saw some examples at Aberdeen, Md., recently, and which public-utility companies are operating.

An impetus has been given since the war to the operating end of the business. I believe it has been true that the operators as a whole have constituted the experimental field for the manufacturers. Not enough experimental work has been done at the factory and there should have been closer cooperation a long time ago between these two groups.

Regarding the work of the Subcommittee on Regulation, in studying the Society's roster I fail to see that any other group of men in the Society is engaged in legislative activities at present. The Standards Committee group as a whole shows that manufacturers are represented largely. The Society is an engineering organization whose membership was composed mainly of men in the designing or manufacturing

[4] M.S.A.E.—Manager of sales promotion department, International Motor Co., New York City.

[5] M.S.A.E.—Chief field service engineer, White Motor Co., Cleveland.

[6] M.S.A.E.—Superintendent of transportation department, San Francisco division, Pacific Gas & Electric Co., San Francisco.

[7] Associate editor, *Bus Transportation*, Chicago.

[8] M.S.A.E.—Superintendent of motor equipment, Standard Oil Co. of New Jersey, Baltimore.

end of the business. But as we view the natural growth of the Society into the operation and maintenance field, it seems to me there must be a spirit of cooperation between the manufacturers and the operators if we are to have the best all-round results.

We are all interested primarily in economical transportation, and if the Subcommittee on Regulation is not a proper division of the Operation and Maintenance Committee but should be a part of some other branch of the Society, the next presiding officer should rearrange this group of men so that whatever objections are made to it can be ironed out.

Factories Need Data from Operators

Mr. Scaife:—I assure you that the manufacturers wish to cooperate with the owners. As I listened to Mr. Wood's report I thought that if I were a designing engineer I would go home and tear up all the drawings and start all over, because his data provide food for serious thought about the whole subject. On the other hand, the engineer does cooperate, but it is very difficult for an engineer or an engineering organization to fit a vehicle of a certain size to every type of transportation. One difficulty we have to contend with as much as with any other is having customers buy vehicles for a price to put into a certain class of work for which larger trucks should be used and, as soon as they get the vehicles, change the tire and other equipment. We manufacturers have to bear the brunt of the troubles that follow.

I cannot agree that all the experimental work is done in the field. True, the proper place for that is at the factory, but we can spend thousands of dollars in the laboratories and, regardless of how we go at it, not get the answers the operators get in the field. A summary of the kind Mr. Wood has given is of the greatest value, because it brings out the various points from an operation standpoint. This report is too voluminous to analyze quickly; it hits the subject from every angle, and it would take 6 months to analyze the subject matter presented and abstract all that is in it, because it touches the vital points of the whole business.

Criticisms by Users Are Invaluable

F. A. Whitten[9]:—Accusation was made that the manufacturers use the operators as an experimental staff. I believe that this is somewhat inevitable. I have had considerable experience for many years in building commercial vehicles and have operated experimental vehicles many thousands of miles and made many changes. Yet, when the supposedly perfect vehicles went out in service, changes that we never thought of were found necessary. I feel that this condition must continue for many years.

The sort of criticism and comment that Mr. Wood has given us is invaluable and is worthy of much study. Most of the faults are not new to us but they cannot be corrected at once. If we attempted to correct all the defects we should be correcting them all the time and could produce nothing. Nevertheless, the information of that sort coming to the factory is invaluable and more attention is paid to it than the outsider thinks, but it seems and frequently is a long time before the operator gets a result from it.

Cast-Steel Drums Reduce Brake Wear

J. H. Watrous[10]:—It seems to me that much of the wear of brake linings has been influenced by the type of drum used. I think more interesting facts on the increased wear-factor of brake linings would be brought to light through changing the type of drum. For instance, if the carbon content of a brake drum were raised from 10 points to 35 points, I believe the life of the brake lining would at least be doubled.

Mr. Wood:—Several fleet operators on the Pacific Coast have found it necessary to change from the pressed-steel type of drum to a special design of cast-steel drum. They have changed to a cast-steel drum that is over-size, using a standardized lining and are getting wonderful results. They have also found it to their advantage to shop around for such equipment. Eastern manufacturers have sent out various types of drum that have decreased the brake-lining and brake-drum maintenance, materially decreasing the cost. We may have to go further than that if we find from these analyses that the component parts are not giving what we believe to be an economical life.

[9] M.S.A.E.—Chief engineer, American Car & Foundry Motors Co., Detroit.

[10] M.S.A.E.—Western representative, Ferodo & Asbestos, Inc., San Mateo, Cal.

[11] Traffic engineer, Berkeley Police Department, now research fellow, Albert Russel Erskine Bureau for Street Traffic Research, Harvard University, Cambridge, Mass.

WHY TRAFFIC ACCIDENTS HAPPEN

Pedestrian Thoughtlessness and Drivers' Poor Judgment Found To Be Chief Causes

Results of a traffic survey made at Rose and Grove Streets, Berkeley, Cal., by C. P. Taylor[11], are summarized by him in the following tabulation of accident causes and are commented upon as reported herein. Mr. Taylor feels that the information collected during the survey exemplifies conditions prevalent throughout the United States and that the report and its conclusions may therefore be viewed in the light of an analysis of a representative sample of street traffic in American cities as well as being an analysis of the traffic and the causes of accidents at the street intersection named above.

TABLE 1—SUMMARY OF INDIVIDUAL ACCIDENTS

Actual Causes	Causes as Assigned by Persons Involved	Observer
Failure of Pedestrian to Observe Traffic	0	4
Lack of Good Driving Ability	0	13
Driver Not Alert	0	2
Drivers Skylarking	0	2
Speeding	3	1
Failure To Yield Right-of-Way	1	0
Overcrowded Automobile	1	0
Failure To Signal	1	0
Motorman Departing from Custom	1	1

It is seen from Table 1 that in several cases the persons involved did not assign a cause to the accident. This is due principally to the fact that they were ignorant of the causes or failed to fill out the accident form completely. In Mr. Taylor's own assignment of causes, as an observer, he states that he made every effort to list the fundamental causes of the accidents and feels sure that his allotments are reasonably correct. Of the pedestrians struck at the intersection surveyed, he states that 100 per cent came to misfortune through their own fault; they did not look before stepping into the street. This forms a splendid check with the study made in his report, in which 34 per cent of the pedestrians were observed not to be watching the passing traffic.

Of all the vehicle operators involved in accidents, Mr. Taylor found that 65 per cent did not use good driving judgment. This, he remarks, gives an insight into the reason for the so-called "upper strata" of society having more accidents than does the delivery boy or the truck driver. Apparently, the professional driver possesses better driving judgment than does the other class. To show that automobile driving is a matter of judgment, he mentions that the traffic slowed down considerably when the street surface became wet or the traffic congested, saying

further that this is representative of good driving judgment and that no amount of law, or law enforcement, can replace it.

Ten per cent of the drivers were not alert, according to the report. Putting all the groups mentioned into one group, which might be termed "thoughtlessness," it is found that 76 per cent of all the persons involved in these accidents were utterly thoughtless and entirely oblivious to the fact that an accident was imminent. Mr. Taylor asserts that he could find only one case in which there was clear evidence that the driver of a vehicle was exceeding the speed limit. The estimated speed in this case was between 20 and 25 m.p.h., which ordinarily might be termed safe and in his opinion is safe if the driver is alert and exercises good driving ability. Failure to yield right-of-way, overcrowded automobile and failure to give a signal were the remaining causes listed by the vehicle drivers, all of which in Mr. Taylor's opinion are subservient to his list of fundamental causes as an observer. In 75 per cent of the cases, both parties involved in the accident were to blame, and 100 per cent of the accidents were avoidable.

Governing Causes of Traffic Accidents

Based upon his experience at the scenes of many accidents and because of great familiarity with accident reporting, Mr. Taylor concludes, first, that if traffic violations were the principal criterion of the number of traffic accidents, then, with an estimated number of traffic violations of more than 1,000,000 a day, there should result an average of more than 4 accidents per day. This fact, allied with the study of the sample accidents, indicates that *violation of the traffic laws and rules is not the governing cause of traffic accidents but that (a) failure of pedestrians to observe traffic, and (b) lack of good driving ability on the part of vehicle drivers are the governing causes.*

The detailed report made by Mr. Taylor seems to him to show that in reality we *know* very little regarding the basic causes of traffic accidents and much less about the proper methods to apply for cures. We have been and still are stumbling around in the dark trying first one idea and then another, pinning all our faith on legislation, or rigid enforcement, or severe punishment, or mass education, or what not; yet the accident toll continues to increase. He says it tempts us to question whether we are on the right track and to ask if we are not as far wrong in attacking the accident problem by our present methods as we were in days gone by when we imprisoned insane persons in penitentiaries to punish them so that they would be good citizens upon their return to civil life. Quoting from Boyd Fisher's book on Mental Causes of Accidents, Mr. Taylor points out that the author touches a fertile field for study of the traffic-accident problem, one directly in line with the findings of his report, when Mr. Fisher groups the mental causes of accidents as being due to minds that are

(1) Unguarded
(2) Puzzled
(3) Misguided
(4) Stubborn
(5) Involuntary
(6) Diverted
(7) Troubled
(8) Affected by physical causes
(9) Tired

In Mr. Taylor's opinion, the unguarded mind exemplifies the fundamental reason why Los Angeles was so successful in reducing the number of accidents to pedestrians when the city enforced the pedestrian law and so compelled the pedestrians to move only with the traffic signals. Pedestrians were simply prevented from rushing headlong into passing vehicles. But he believes that the establishing of such a practice in a city in which dense pedestrian traffic is rare is of doubtful value. Where pedestrian traffic does not interfere materially with the vehicular flow and the walking public is encouraged to make use of the traffic signals for its own safety, it seems unfair to harness the freedom of every law-abiding citizen at controlled intersections for the sake of some two or three individuals who have not learned to look before stepping into the streets. He therefore feels that curtailing the freedom of so many people is wrong, but admits that the subject is debatable.

Must Put a Premium on Carefulness

This investigation in Berkeley is reminiscent to Mr. Taylor of the days when traffic problems first made themselves felt. It scraps the present belief that all traffic accidents will disappear with strict enforcement and elevates more than ever the idea that education is the goal. But he asks how we can deal positively and effectively with such intangible human frailties as failure to observe and failure to exercise good judgment. Should a logical and rational method for dealing with these governing traffic-accident factors be offered, it is his recommendation that it be utilized, but he asserts that such a plan cannot function unless it can make people want to be careful. For any plan to be successful, it must put a premium on carefulness and so great a stigma on carelessness that no individual can possibly ignore the rules of safety without justly suffering the consequences. Thus carefulness will really be made worthwhile.

Mr. Taylor states that if every accident were considered as important as a murder, and as rigid an investigation were made and a report filed, including photographs, statements, diagrams, and deductions, and every clear-cut case of recklessness, gross negligence and drunkenness were successfully prosecuted and the violators severely punished regardless of the disposition of the damage settlement, and if every damage suit were supplied with the most convincing and conclusive background of unimpeachable evidence, we should find that this would be *one way of making every individual take it upon himself not to have an accident.*

A Method of Making People Think

People would, in his opinion, soon learn that it is incumbent upon them to drive and to walk so as not to have an accident; for, if they should become careless and an accident should result, they would be held responsible for the damage done and would be liable to criminal punishment. Here, perhaps, suggests Mr. Taylor, we have a method of causing each individual to think and to learn how to use the streets without having an accident. It places the responsibility upon the individual to become educated by the safety rules and eliminates the necessity for the superhuman efforts of the community to force education into unwilling minds.

Complete records of each driver, if kept on file, would have a salutory effect. Mr. Taylor remarks that a record system similar to that used for criminals would be satisfactory and would include all the difficulties that each driver has encountered. Such a file could be operated in conjunction with the records of the State Motor Vehicle Department, so that data could be kept regarding local offenders even when they are outside of a city. If a certain driver proved himself to be an unfit automobile operator, he could be barred from driving, and the community would profit greatly. This would then be another incentive for more careful driving. Moreover, this record system could easily be used as a basis for awarding a medal or prize for the most careful drivers, in this way creating a constructive desire through competition to be ranked among the best drivers. Every effort should be made to honor good drivers and to eliminate the poor ones. The study simply shows, says Mr. Taylor, that poor drivers do several times more damage than criminals and must be dealt with just as intelligently and severely.

Production Engineering

PRODUCTION ENGINEERS' CONFERENCE

Plans for Production Activities of the Society Discussed during Annual Meeting

Before the production session of the Annual Meeting, held in Detroit on the evening of Jan. 26, there was a dinner-conference to which a number of company executives and production men were invited for the purpose of discussing the production activities of the Society.

J. H. Hunt, then President of the Society, acted as chairman of the meeting and spoke of the desire of the Council to give a more prominent place to production activities in the Society's programs. With this end in view, the Production Advisory Committee was organized last year. However, it is felt that the work cannot proceed effectively without greater interest on the part of the production men.

W. G. Wall, then President-Elect, mentioned the great assistance the Society has given to designing engineers and others, particularly stressing the value of the standardization work, and expressed the opinion that the relative importance of designing and production engineers is now shifting, with emphasis tending toward production. The Society, he said, can be of as much benefit to the production engineer as it has been to its other members.

Production men are now the key men of the industry, according to E. P. Blanchard, of the Bullard Machine Tool Co. Apparently they have not had so much time to take a very active part in these functions of the Society and many of the executives do not feel that they should so devote their time. He feels that the problem is to secure the support and encouragement of the company executives in these activities, and that this support will be forthcoming if important common problems are presented for solution. He suggested an organization somewhat as follows:

(1) An advisory group of leading company executives who would give their advice and backing but would not be asked to do committee work
(2) A committee of production engineers who would be responsible for the active work
(3) Subcommittees for specific groups of problems, the chairmen and members being selected from among the members of the main Production Committee

Mr. Blanchard proposed the following groups or classifications of subjects as examples of the problems which should be taken up:

(1) Material handling and control
(2) Processes and equipment
(3) Production expense (costs and budgets)
(4) Time study and personnel relations
(5) Production standards
(6) Publication and Section activities on production

Eugene Bouton, of the Chandler-Cleveland Motor Car Co., suggested that there be a vice-president of the Society for production and a production man at the Society's office in charge of the work. He also added to Mr. Blanchard's list the following subjects for consideration:

(7) Depreciation of reserve
(8) Organization
(9) Standardization of machine-tools

Mr. Hunt replied that the Council of the Society has given much study to the question of reorganizing the administrative officers of the Society, including the creation of vice-presidencies, but has not yet done so largely because of lack of interest and a common viewpoint among the members regarding such changes.

Speaking for J. H. Teachout, production manager of the White Motor Co., A. K. Brumbaugh recognized the tremendous advantage that has come to the automotive industry through the cooperation of designing engineers and expressed the belief that this cooperation could well be extended to the production men, if a suitable organization and procedure were developed. He said that human beings are naturally inclined to be suspicious of things with which they are not thoroughly familiar, and that, if the Society can be of help to production men, means for working out their problems can be found.

That great benefit has already accrued to production men who have followed the activities of the Society was stated by W. W. Norton, of the Autocar Co., who also expressed the opinion that the key to the situation lies in acquainting the chief executives of the industry with the possibilities and activities of the Society along production lines; mentioning that great benefit has come from the contact and intercourse between designing engineers but that the production men do not find it easy to attend meetings. Mr. Norton suggested that most of the production activities be planned for the benefit of the companies whose output is relatively small, as they are the ones that most need the help.

Production Standards Wanted

Production standards and data sheets were mentioned by G. D. Babcock, of Dodge Bros., Inc., as one of the most important things the Society could furnish for production engineers, as many of the data appearing in ordinary mechanical handbooks do not apply to automobile manufacturing or are considered more or less unreliable. He said that, if production standards and data covering the needs of the automotive production man could be prepared with the authority of the Society behind them, they would be used extensively. Belt transmission was suggested as one subject upon which data should be given. Mr. Babcock also mentioned papers on lapping processes at the Dodge and other plants that had gone into the matter very thoroughly and given much information of value to production engineers and managers.

Need of a man at the Society headquarters who can devote his time to the work of a production committee was expressed also by G. W. Blackinton, of the Continental Motors Corporation, who suggested taking up work on machine-tools, especially those for handling the heavier parts of automotive engines. He felt that plans for reducing the physical effort required in handling such work should be furthered.

More production meetings in production centers were thought by L. F. Maurer, of the Studebaker Corporation of America, to be the means for better results in the work of the Society.

How To Increase Production Membership

Further extension of the Society membership among production men was suggested by A. R. Fors, of the Continental Motors Corporation, this extension to be secured by the efforts of the present members among the production men in their own organizations. There is almost no limit to what can be accomplished by more cooperation with and among production men, he said.

R. S. Burnett, manager of the Society's Standards Department, explained that the design standardization work of the Society is done by the members of the Standards Committee rather than by the staff, which serves more in

the capacity of executive secretary to the several committees. One of the chief difficulties he has found in connection with the production work is that the production men are not so free to devote their time to committee work as most of the other members of the Society. He also mentioned that the Society has recently adopted its first production standards and that these are available separately in published form.

In closing the meeting, President Hunt confirmed Mr. Burnett's statements in regard to the present functions of the Society staff, which is intended to operate as a clearing-house. He sensed the feeling that the same form of organization and procedure as for design standards may not be effective for production men and requested that any further suggestions for the production activities of the Society be submitted to its New York City office.

Largely as the result of this conference, the organizing of a Production Advisory Board, consisting of presidents and vice-presidents of automobile companies, and of the S.A.E. Production Committee, was well under way before this issue of THE JOURNAL was printed. This committee is divided into seven groups or subcommittees, each of which will study production projects coming under one of the following broad classifications:

(1) Material handling and control
(2) Processes and equipment
(3) Time study and personnel relations
(4) Production expense (costs and budgets)
(5) Production standards
(6) Inspection methods.
(7) Section activities on production

As soon as the personnel of these groups is completed, particular attention will be given to developing and expediting their activities in a way best suited to the production men in the industry.

INSPECTION OF ARC-WELDED JOINTS

Inspectors Should Learn Characteristics of a Good Joint by Watching a Welder

At a meeting of the Northern California Section of the Society last fall, James C. Bennett, manager of the automotive department of the Associated Oil Co., and past-chairman of the American Welding Society, was asked how an inspector can tell whether good welded joints have been made. The question came up primarily in connection with butt joints in structural steel work and steam boilers, but his reply is equally applicable to other classes of welded work in steel, not in other metals.

Mr. Bennett said that an inspector who is accustomed only to inspecting riveted joints can hardly be expected to be able to judge welded joints without some training. A committee that discussed the subject decided that it would not be able to issue printed instructions that would be adequate.

The inspector should put on a mask and watch some welding work to learn its appearance. It is a good plan to get an adept and highly skilled welder to make a good weld and a poor weld, and to watch the pool of molten metal near the arc. Metal should be deposited first in the bottom of the V at the point where the two parts meet, gradually building up to fill the trough.

As the arc travels along the seam, a progressively cooling pool of molten metal is left behind. If a skin of oxide forms quickly on this pool, it is evidence that the joint will be brittle. If the cooling is relatively slow and without oxide, the weld almost surely will be ductile.

The result depends largely on the quantity of current and its relation to the diameter of the electrode. Too heavy a current will cause burning and too light a current will not produce true fusion. Reliable tables are available showing the relation of current and of electrode diameter to the thickness of the metal to be welded.

To assist in the inspection, it is well to have the welder leave a crater when he finishes the weld. An inspection of that and of the uniformity of the seam will give a safe guide as to the penetration of the weld. This and relative freedom from oxide, indicating slow cooling, are the principal points to watch in inspection.

AUTOMOTIVE GRINDING COMPOUNDS

Fine Abrasives Said To Cut as Fast as Coarse—Soluble Oil Recommended

A recent investigation has uncovered information regarding the use of grinding compounds in some of the large plants where automobiles and automotive engines are manufactured. In many cases the practice is to purchase commercial valve-grinding compounds such as meet with the approval of the department in which they are used, no tests being made except to see which compound will do the work well enough to pass inspection in the shortest possible time.

Tests were made in one organization to determine the attrition of discs rotating under standard conditions of speed and pressure with a number of different commercial compounds in different grades. These tests seemed to show that the degree of fineness has little effect on the weight of material ground away.

Another organization makes it a rule to use no abrasive coarser than rotten stone. Grinding with a coarser abrasive is said never to result in a tight valve, and such an abrasive should not be used in manufacturing work. In the field, where means are not available for machining the valve and seat accurately, coarser abrasive may be used.

Another manufacturer, who does not seat his valves directly in the engine cylinders, makes his own grinding compound by mixing either silicon-carbide or aluminum-oxide grains in soluble oil to a pasty consistency. He emphasizes the importance of using soluble oil because of the readiness with which the abrasive compound can be washed off the parts in an ordinary washing-machine, in contrast with the difficulty encountered with other than soluble oil.

PRODUCTION-STANDARDS BINDERS

Society Not to Carry Stock for Letter-Size Pamphlet Issues

Since the Society issued in letter-size form its first two Production Engineering Standards, namely those for Taps, Cut and Ground Threads, and for T-Slots, Bolts, Nuts, Tongues and Cutters, several inquiries have been received as to obtaining three-ring binders for them from the Society. These binders will not be furnished by the Society because they are a regular commercial standard and are usually obtainable through any stationery store.

Publication of the standards in this form was decided upon as a result of the recommendations of production engineering members. The principal reason was that the pamphlets will fit any standard stock three-ring loose-leaf binder. This is a common method of filing data by the production engineers and standards issued accordingly can readily be inserted in their current files. Where such standard three-ring binders cannot be obtained readily from stationery stores, the Society will assist the members in securing them.

Since issuing the two standards pamphlets referred to above, it has come to the Society's attention that the punching in them was not standard. This error will be remedied in future issues so that they will fit an 8½ x 11-in. binder punched with three holes spaced 4¼ in. center to center. Meantime, members wishing to file the copies they have received can readily repunch their copies to conform with the standard three-ring spacing.

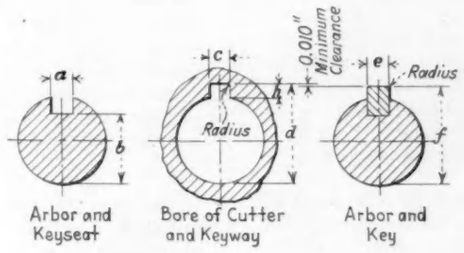
MILLING CUTTERS AND ARBORS

Proposed Keys and Keyways Standards Submitted for Review by Industrial Users

Among several projects that are now in progress relating to machine-tool standardization is that of establishing standard keys and keyways for milling cutters and arbors. A Committee on Milling Cutters, organized under the Sectional Committee on Small Tools and Machine-Tool Elements that is sponsored by the Society, the American Socity of Mechanical Engineers and the National Machine Tool Builders Association, under the procedure of the American Engineering Standards Committee, submits the tentative proposal shown in the accompanying drawing and table for careful review by industrial users to determine the acceptability of the report before it is presented for final approval by the Sectional Committee and its sponsors.

The Committee is composed of representatives designated by the sponsors from the machine-tool manufacturers, the general mechanical industrial users and the automotive industry. It is necessary, however, that proposals of this kind be studied by the industries at large to make sure that the proposals of a relatively small Committee meet the requirements of general industrial practice in formulating a standard such as this.

Comments on the proposed recommendations therefore are solicited by the Committee. Criticism or suggestions relating thereto should be addressed either to the Society or to the American Society of Mechanical Engineers, at the New York City offices, or to J. B. Armitage, care of the Kearney & Trecker Corporation, 60th and National Avenues, Milwaukee.



PROPOSED KEYS AND KEYWAYS FOR MILLING CUTTERS AND ARBORS STANDARD

Diameter of Arbor	Nominal Width of Key	Arbor and Keyseat		Bore and Keyway				Arbor and Key		
		A	*B*	*C*	*D*	*H*	Corner Radius	*E*	*F*	Corner Radius
½	3/32	0.0937 0.0947	0.462 0.457	0.099 0.106	9/16	1/16	1/64	0.0937 0.0927	35/64	1/64
5/8	1/8	0.125 0.126	0.575 0.570	0.130 0.137	45/64	5/64	1/32	0.125 0.124	11/16	1/32
3/4	1/8	0.125 0.126	0.700 0.695	0.130 0.137	53/64	5/64	1/32	0.125 0.124	13/16	1/32
7/8	1/8	0.125 0.126	0.825 0.820	0.130 0.137	61/64	5/64	1/32	0.125 0.124	15/16	1/32
1	1/4	0.250 0.251	0.850 0.845	0.255 0.262	1 1/64	1/8	3/64	0.250 0.249	1 3/32	3/64
1 1/4	5/16	0.3125 0.3135	1.063 1.058	0.318 0.325	1 25/64	5/32	3/64	0.3125 0.3115	1 3/8	3/64
1 1/2	3/8	0.375 0.376	1.275 1.270	0.385 0.410	1 21/32	3/16	1/16	0.375 0.374	1 41/64	1/16
1 3/4	7/16	0.4375 0.4385	1.488 1.483	0.448 0.473	1 15/16	7/32	1/16	0.4375 0.4365	1 59/64	1/16
2	1/2	0.500 0.501	1.700 1.695	0.510 0.535	2 7/32	1/4	1/16	0.500 0.499	2 13/64	1/16
2 1/2	5/8	0.625 0.626	2.125 2.120	0.635 0.660	2 25/32	5/16	1/16	0.625 0.624	2 49/64	1/16
3	3/4	0.750 0.751	2.550 2.545	0.760 0.785	3 21/64	3/8	3/32	0.750 0.749	3 5/16	3/32
3 1/2	7/8	0.875 0.876	2.975 2.970	0.885 0.910	3 57/64	7/16	3/32	0.875 0.874	3 7/8	3/32
4	1	1.000 1.001	3.400 3.395	1.010 1.035	4 7/16	1/2	3/32	1.000 0.999	4 27/64	3/32
4 1/2	1 1/8	1.125 1.126	3.825 3.820	1.135 1.160	5	9/16	1/8	1.125 1.124	4 63/64	1/8
5	1 1/4	1.250 1.251	4.250 4.245	1.260 1.285	5 9/16	5/8	1/8	1.250 1.249	5 35/64	1/8

Cooperation

A VERY fundamental principle lies at the bottom of all cooperation, namely, that the various interests fundamentally concerned in any project are not really antagonistic. There is a solution of every problem and this will be not only best for the public but best in the long run for the various interests that are concerned. The problem is primarily not one of give and take but of working together to discover the best thing on which all can unite. Resultant identification of interests comes from association.—Albert W. Whitney.

Standardization Activities

TAIL-SKID SHOE ATTACHMENT

Mounting Dimensions of Shoes of Airplanes under 4500 Lb. Proposed

The illustrations herewith describe the proposed standardization of tail-skid shoe attachment which has been prepared by a Subdivision of the Aeronautic Division, the personnel of which Subdivision is as follows:

T. P. Wright, chairman, Curtis Aeroplane & Motor Co., Inc.; J. A. Roché, Air Corps; Mac Short, Massachusetts Institute of Technology.

The report has been worked up on the basis that the standardization has to do with the dimensions and arrangements involved in the interchangeability of tail-skid shoes and basically has no concern with the actual design of the shoe or skid. Several of the sketches illustrate the adaptability of two types of shoe to the proposed standard mounting dimensions.

The spoon shoe illustrated is intended to be a type suitable for use with wheel brakes, although the design of this shoe is no part of the standard. Shoes for airplane-carrier use are thought to be a too specialized product to be considered for standardization, although the spoon-shoe design has been used on airplanes for shipboard use.

Comments from Aeronautic Division Members

The proposed mounting dimensions were submitted to the members of the Aeronautic Division for comment and portions of a number of interesting comments received are quoted herewith.

After perusing the letter and the blueprints on the suggested standard tail-skid shoe mounting, I wish to assure you that I am in accord with the recommendations.

Of course it is understood that this standardization is for airplanes up to and including those weighing 4500 lb.

We have studied the proposed specification for tail-skid shoes and the drawing, and find it acceptable as is.

As an operator and pilot, however, I believe that the standardization of tail-skid shoes is of considerable importance. These shoes have a bad habit of wearing out at inopportune moments, and if it were possible to secure interchangeable shoes in various parts of the Country, it would be of considerable advantage. The proposed specifications appear to me to be very satisfactory.

Suggests Need of Larger Bolts

There is little need to standardize on the type of contour of tail-skid shoes; the main feature of the standardization is to control the size and location of the holes in the skid and the shape of the skid to which the shoe is attached. So far as I can see at present, the proposed design will be satisfactory for airplanes under 4500 lb. gross weight.

To criticize its proposed dimensions for tail-skid attachment, I would suggest that 5/16-in. bolts be used in place of ¼-in. It has been our experience that the large size is desirable from the consideration of durability, especially when a metal shoe is bolted to a metal tube. The dimensions proposed were copied from the DH design, in which the shoe was bolted to a wooden tail-skid, under which condition the smaller bolts will give greater life than when used in a tubular tail-skid when the bearing pressure is greater, due to the thin edge of the steel which will cut into the bolt.

If you wish you may suggest to the Standards Committee that the size of the bolts be increased in diameter to secure greater serviceability. The style of the shoe will be governed by the design of the tail-skid, as you know a steerable tail-skid may have a large rib on the shoe while a non-steerable tail-skid should have a spoon-type shoe.

We are making a thorough study of tail-skid shoes at the present time and may have something interesting to offer within the next few months.

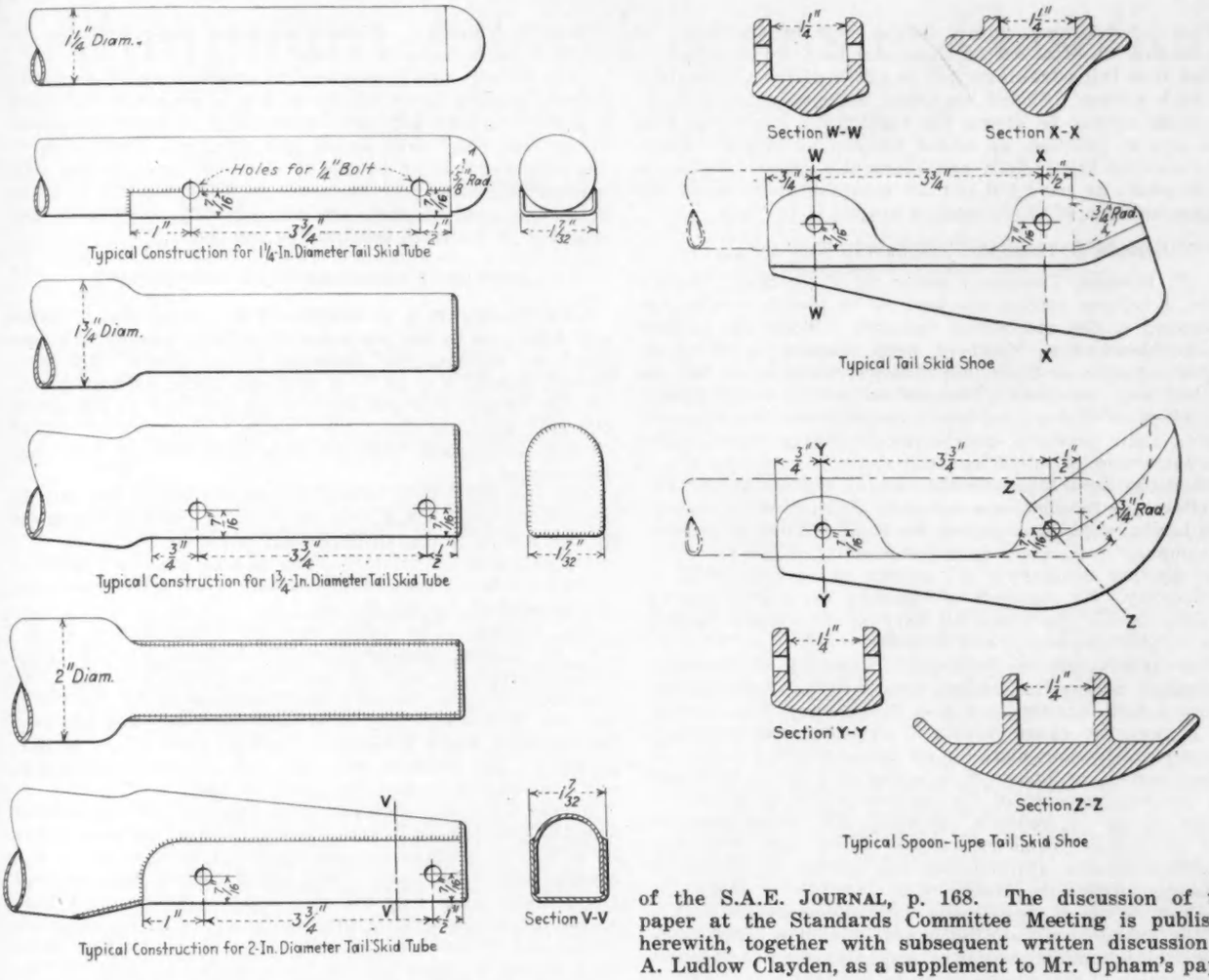
The general proportions of the proposed standard tail-skid shoe are satisfactory, but it has been our experience that considerable fitting at assembly is necessary if the shoes are made to the same dimensions as the tube on which they fit. It is recommended that clearance be provided by substituting for the dimensions, namely, 1¼ and 7/16, the dimensions 1 9/32 and 17/32 respectively.

I have perused the blueprints of the proposed tail-skid shoes and tubes submitted by the Subdivision and heartily approve of the entire design. They are to be commended in bringing this part of the work to a head, and I trust that other members of this Division will agree that the design submitted is complete and satisfactory in all respects.

I suggest that the tail-skid tube illustrated for the 1¼-in. diameter tube be adhered to to avoid cost of production. The size of tube should increase with the weight of the airplane. The tube is subjected to bending and therefore must have an increase in diameter with the increase in the load and moment.

Not a Skid or Shoe Standard

It is believed that the point should be stressed that this is a standardization of tail-skid shoe attachments rather than for tail-skid shoes or tail-skid. I do not believe that we are in a position at present to adopt a standard for either tail-skids or tail-skid shoes. I do believe that what the Subdivision has attempted to do, namely, standardize the attachment so that shoes may be interchangeable, is feasible at the present time. It seems to me, however, that the Subdivision has lost sight of the fact that the tail-skid shoes will, in general, be of unfinished manganese steel or some similar wear-resisting metal in the form of castings. This being the case, it will be necessary to provide ample clearances to ensure proper fits. It is noted, for instance, that the distance from the center of the bolt holes to the face of the shoe is given as 7/16 in., the same as the corresponding dimension of the skid. In general, such a combination will not work. There should be at least 1/16-in. clearance. I do not believe that the 1/32-in.



difference in width is sufficient either, as the opening in the skid will probably have a certain amount of draft.

The report and the comments thereon will be submitted to the Aeronautic Division at a meeting in April for consideration and action.

NUMBERS FOR OIL VISCOSITIES

Animated Discussion at Standards Committee Meeting for and against S.A.E. System

Marked advance has been made for several months toward greater use, by both oil-refining companies and motor-vehicle manufacturers, of the numbering system for lubricating oils as specified by the S.A.E. Recommended Practice on p. 390 of the S.A.E. HANDBOOK, September, 1927, issue. Many of the oil refiners indicate on their oil containers and in their lubricants charts the S.A.E. Numbers corresponding to their various and several grade-designations, and the vehicle manufacturers are indicating similarly in their instruction books the oil viscosities recommended by them for seasonal use in their engines. In some instances it is proposed to put this information on the oil filler-pipe cap on each engine.

E. W. Upham, chairman of the Lubricants Division of the Society's Standards Committee, presented at the Standards Committee Meeting in Detroit in January a comprehensive paper on the underlying reasons for using this system, and his paper was published in the February issue of the S.A.E. JOURNAL, p. 168. The discussion of this paper at the Standards Committee Meeting is published herewith, together with subsequent written discussion by A. Ludlow Clayden, as a supplement to Mr. Upham's paper.

THE DISCUSSION

G. A. ROUND, Vacuum Oil Co.:—The company I represent does not consider it advisable to adopt the S.A.E. numbering system, for the following reasons.

As to the system itself, the classification of oils having viscosities between the various ranges, in the next lower range, does not seem entirely fair. In our opinion there should not be any such breaks. This, however, is of far less importance than the way in which we think the S.A.E. Numbers will be interpreted to and by the average oil-user.

Thus far the use of S.A.E. Standards has been confined entirely to those who are thoroughly familiar with their significance and limitations. We feel, however, that the S.A.E. Numbers are proposed as a means for telling the public what grade of oil to buy, and this immediately sets up oil viscosity at a single temperature as a complete measure of oil quality. It indicates in effect to the layman that all oils bearing the same viscosity-number are equally satisfactory. As engineers we know this is not so but, when the instruction "Use oil having S.A.E. Viscosity Number 30" appears on the filler pipe, what else is the layman to believe? Even if a full explanation is given in the instruction book, how many will read it? This impression is already being fostered and capitalized upon by oil companies, oil salesmen and the unscrupulous substitutors of inferior oils for trade-marked quality oils. They are going even further and trying in every possible way to lead the layman to believe that their oils carry the endorsement of the S.A.E. We have advertising literature and confidential letters issued by companies which conclusively prove this.

This is, of course, unfair but so long as the name of the Society is attached to these numbers it must be expected that full advantage will be taken of the opportunity for such misuse. Should we adopt the numbering system, we would simply be giving the substitutor, who even now is a serious problem, an added weapon of attack. From our viewpoint this is fully as important a sales objection to the numbers as some but not all manufacturers claim the recommendation of trade-marked brands is to them.

Numbers Represent Viscosity, Not Quality

O. E. Eckert, Transcontinental Oil Co.:—Mr. Upham's paper, I believe, strikes the keynote in proper lubrication as applied to the automotive industry. When the revised S.A.E. Specification Numbers were adopted in 1923, we adopted them and made our oils to conform so far as viscosity was concerned. That did not enter into the matter of quality. Different refiners have different processes of refining their products and their advertising departments have their way of advertising the quality.

There has been a great difference of opinion among the oil refiners as to what was meant by light, medium, heavy, extra-heavy, super-heavy, and so forth. This is because one company's oil, which is called medium, is 700-viscosity, while another company's oil, known as medium, will be 500-viscosity. No standard of viscosity has existed among the refiners and their oils all vary as to what is known as light, medium, heavy, and so forth.

With the adoption by the Society of the S.A.E. Viscosity-Numbers, I believe the refiners should adopt them. When we say S.A.E. Specification No. 20 we know that the oil has a viscosity range within a certain maximum and minimum. If a man buys his oil to a certain S.A.E. Viscosity Number, he knows it is within the range that will meet the requirements of the particular car he drives.

Some of the oil refiners, perhaps, will be reluctant to adopt the S.A.E. Numbers for the reason that they have established certain brand-names and carried on extensive campaigns advertising them. Our company is doing the same, and the use of the viscosity numbers does not interfere with the brand names or the grades we have established. We tell the automotive engineer and the man who is using the car which of our grades of oil to use that comes within the viscosity range of the S.A.E. Numbers, and are not worrying about the man who may try to sell an inferior grade of oil. The numbers do not represent quality but do represent that factor of lubrication that is always necessary—viscosity.

Not Afraid of Competitors' Advertising

Our company issues a chart for every car, automobile truck and tractor, giving our recommended oil as light, medium, medium-heavy, or whatever it should be, following which we give the S.A.E. Number for that oil viscosity. We use this in our advertising and sales work. We are instructing our service-stations to advise the operator who comes in for lubricating oils to call for them, not by grade names, but by S.A.E. Numbers. We are not losing the value of our trade-mark by so doing. In fact, it has been a pleasing surprise to note the reception of this system in all parts of the Country where we are marketing our oil. The demand is being created by the automobile operator who is learning the use of the S.A.E. Numbers for viscosity and depending on the refiner for the quality of the lubricant. We are willing to depend on our ability to produce and sell quality oils and are not afraid to use the S.A.E. Numbers on them. The unscrupulous or the little compounder in the country town, who is interested only in the nickel he can make by selling a quart of oil, may adopt the S.A.E. Numbers and use them in marketing his oil locally. However, the Society has a list of manufacturers and producers in the S.A.E. Handbook who certify that their products conform to the Society's specifications and the oil refiner who cares to do so can certify that his product conforms to the S.A.E. Viscosity Numbers. It does not seem likely that the unscrupulous dealer will do this.

The refiner who is striving to cooperate with the automotive manufacturer will be willing to maintain the standard for viscosity and not worry about competitors advertising that they have an oil just as good. That is up to the refiners; it is up to nobody else. We are meeting with wonderful success with the trade in using the S.A.E. Numbers, and even if they are not adopted universally, our company is going to continue to use them.

Implied Endorsement of the Society

Vice-Chairman A. J. Scaife:—I do not see that it makes any difference to the reputable oil refiner, whether his container is marked, for instance, "—— Heavy" or "—— Heavy, S.A.E. No. 30." If you are going to try to outwit the "gyps" you will have a job one way or the other. Nothing prevents the "gyp" dealer from putting "gyp" oil into a reputable refiner's cans regardless of how they are marked.

Mr. Round:—This is the point; the oil is not simply oil No. 30, it is S.A.E. No. 30. The implied endorsement by the S.A.E. is the all-important point.

Vice-Chairman Scaife:—The S.A.E. does not endorse anything. Using the S.A.E. Number is not an endorsement of the product by the Society.

Mr. Round:—The public does not know that.

C. P. Grimes, Quaker State Oil Refining Co.:—I agree with Mr. Round's point of view to a certain extent. I am associated with a company that produces oil in the Pennsylvania field where they have the Pennsylvania-grade producers' label, which is certainly definite as to size, type and number. The refiners who use only Pennsylvania-grade oils are entitled to use this label on their containers.

It has been my observation at various service-stations that the station man in many cases has said that some other oil is just as good as the one asked for because it has the Pennsylvania label on it. That might be true but, whereas one refinery puts only 3½ per cent of the pure oil that comes out of the ground into containers with its name on them, another refinery will put from three to five times that volume of pure oil into its containers. Why? The former says that is its competition oil, it is a pure Pennsylvania product and the refinery is entitled to use the label.

I think that if the refiners will state only three numbers, the fire, flash and the viscosity, on their cans, they can overcome such troubles of having a common label that might be assumed to have the sanction of some society.

Might Use Numbers Without Society Initials

B. B. Bachman, Autocar Co.:—Would not a number without the letters S.A.E., instead of a grade designation such as light, medium or heavy, which we all know does not mean anything, meet the requirements of the motor-car manufacturer and also do something, if not everything, toward eliminating the objections which Mr. Round brings up? After all, we are trying to establish a nomenclature and I do not see how the letters S.A.E. have a place in the nomenclature.

W. G. Clark, Pure Oil Co.:—I believe Mr. Bachman's suggestion answers the objection of most of us who do not like to put the words S.A.E. in front of a specification number. If we were selling oil only to you engineers it would be a different matter, but what good would it do to tell the layman that this oil has a certain viscosity-number? He does not know what viscosity is. If he did, it is not all-embracing so far as quality or suitability of the oil is concerned. I am in accord with Mr. Round's views in the belief that certain members of the oil industry will call the S.A.E. Numbers an endorsement, whether they are that or not. We know that it is not an endorsement, but the public does not know it. It will be

(*Continued on p.* 395)

Aluminum-Alloy Pistons in Gasoline and Oil Engines

By H. A. HUEBOTTER[1]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND CHART

COMPROMISES are necessary in designing a piston, sacrificing the quality of least importance under the given conditions. Aluminum alloy is seen as a most desirable material because of its high conductivity and low rate of absorbing heat from hot gases.

Aluminum-alloy pistons are now made for oil engines with bores up to 18 in., as well as for small gasoline engines, those described in this paper having their expansion controlled by steel bands embedded in the aluminum but not bonded thereto. Slots cast in the piston allow for linear expansion of the alloy without a corresponding increase in piston diameter and change in cylinder clearance.

Advantages of strut-type pistons are shown by thermal diagrams. Illustrations show large pistons and engines in which they are used. Cores and steel inserts for producing such pistons are shown also.

PISTON design presents many major problems to the engine designer. High speed introduces inertia problems, high pressure requires strength, and the heat conditions call for thermal conductivity. The essential features in a successful piston may be listed as follows, without regard for their order of importance:

(1) Light weight, to minimize inertia forces
(2) High thermal conductivity and emissivity, to improve heat dissipation; or refractory composition, to withstand high temperatures
(3) Proper bearing fit in the cylinder at all operating temperatures
(4) Strength adequate to withstand the maximum gas pressure in the cylinder
(5) Effective sealing against the gas in the combustion chamber and against the lubricating oil in the crankcase
(6) Good bearing properties with normal lubrication
(7) Ease of fabrication
(8) Resistance to corrosion in ordinary service

A glance at the above requirements suffices to show that a piston must be the product of a number of compromises. A piston designed for high speed alone will fail when applied to heavy service, as it has not enough metal to conduct the absorbed heat nor to carry the high fluid-pressures. A piston that runs cool indefinitely at full load is too massive for high speed. The less important quality must always abdicate in favor of those which are imperative.

GOOD PROPERTIES OF ALUMINUM ALLOY

Fortunately, a light alloy of aluminum provides material that combines low thermal-resistance and low weight. With a conductivity 3½ times that of gray iron and a density 40 per cent as great, such an alloy offers alluring possibilities to the piston designer, the more so when we consider that the conductivity of aluminum alloy improves as the piston becomes hotter, whereas the reverse is the case with gray iron. To clinch the choice, the alloy absorbs heat from the hot gas less readily than does iron.

But the design of a satisfactory aluminum-alloy piston is complicated by the fact that the metal has a coefficient of thermal expansion about 120 per cent greater than that of gray iron. Despite its lower working-temperature, the simple light-alloy piston usually requires a much greater cold-clearance than does its heavier competitor.

The gray-iron piston therefore has established a practicable working clearance that usually is regarded as the goal for the aluminum-alloy piston. This small clearance is so highly prized for quiet operation that the principal developments in alloy pistons have been directed toward the reduction of thermal distortion in the bearing surfaces. The result of these efforts has put innumerable piston designs into the United States Patent Office and not a few upon the market.

APPLICATION OF ALLOY PISTONS SPREADING

The automobile industry has consumed by far the greatest number of these practicable light-alloy pistons. During the last 5 years, however, other manufacturers of internal-combustion engines have played an aggressive part in applying aluminum-alloy pistons to their product. This development has taken place in response to the same trend in large-engine design that has marked automobile engine growth since its infancy. When high crankshaft-speeds and high mean-effective-pressures are adopted, the piston problem becomes acute and alloy pistons are drawn into service.

Among the present consumers of aluminum-alloy pistons in heavy-duty service are the motorboat and the gasoline rail-car manufacturers. Popular engines for these services develop from 150 to 250 b.hp., with cylinders of 6 to 7½-in. bore. Such engines show 90 to 110 lb. per sq. in. brake m.e.p. at the peak of their torque curves. Considering the duration of service expected of these engines between overhauls, the operating conditions are rather severe.

Another class of service to which aluminum-alloy pistons are being successfully applied is represented by moderate-sized marine, railroad and mobile industrial oil-engines operating on the Diesel or the modified Diesel cycle. These engines are built in cylinder sizes of 5 to 18-in. bore and develop in excess of 100 lb. per sq. in. indicated mean effective pressure.

[1] M.S.A.E.—Chief engineer, Butler Mfg. Co., Indianapolis.

The remainder of this discussion will be devoted to pistons marketed under the name "Bu-Nite," which are represented in practically every class of internal-combustion reciprocating engine now in commercial use and are manufactured in sizes ranging from 2 3/16-in. diameter, for gasoline racing engines, to 18-in. diameter, for Diesel yacht engines. They illustrate certain methods whereby aluminum alloy has successfully displaced gray iron in heavy-duty pistons. The metal, to which the trade name Bu-Nite is applied, is an alloy of aluminum, copper, iron, and nickel, developed for and devoted almost exclusively to the manufacture of pistons and piston accessories.

Bu-Nite pistons are distinguished by their use of continuous steel bands cast into the alloy skirt, whereby the expansion of the skirt is controlled and limited by that of the bands. These control bands may be used in any number. In the present state of development four bands have been found sufficient for the largest Diesel-engine pistons, while gasoline-engine pistons usually are manufactured with one or two bands. The details of construction will be apparent from the illustrations.

Piston discussion is expedited by the use of certain terms which will be defined here for the purposes of this paper. The typical Bu-Nite piston is of the "strut type" in which the pressure of the gas is transmitted from the piston-head to the piston-pin bosses through columns or struts. The conventional piston which carries the load to the bosses by way of the skirt walls is called the "shell type." The term "solid type" distinguishes the continuous skirt from the "band type," wherein the skirt is split longitudinally by compensating slots. A piston may be in both the strut and the solid classes, or it may be a shell and band type. Most of the present pistons are strut and band type although some are made in the shell and solid type. The classifications as to struts and bands are independent.

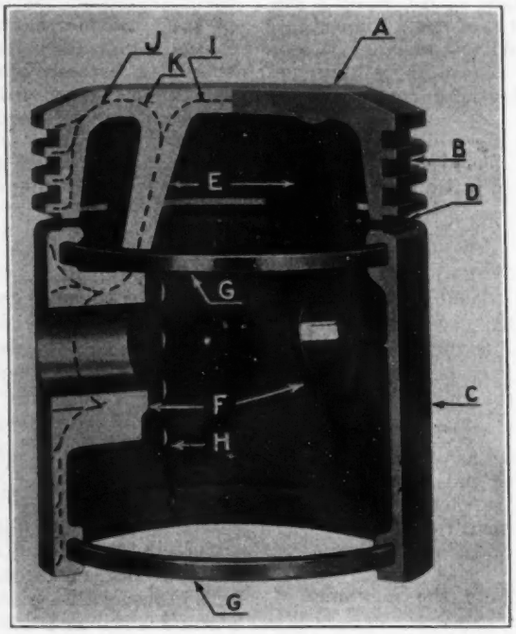


FIG. 1—A STRUT-TYPE PISTON IN SECTION

This Piston Has Its Head and Ring Section Supported from the Piston-Pin Bosses by Struts. The Skirt Is Split, Designated by the Author as "Band Type," Having Two Steel Expansion Control Rings Cast in the Aluminum Alloy but not Bonded. In Large Diesel-Engine Pistons, Four Expansion Control Rings are Used. Dash Lines Show Paths Through Which Heat Is Transmitted from the Head to the Ring Section and Skirt of the Piston

The "compression" of the piston in our parlance indicates the distance from the axis of the piston-pin to the head of the piston, without reference to the pressure of the gas in the combustion chamber. A gasoline-engine piston may have a "long compression" and a Diesel-engine piston a "short compression" although the compression pressure of the gas in the cylinder is more than six times as high in the Diesel engine as in the gasoline engine. The term has come into use for convenience in describing pistons.

Fig. 1 shows a piston of an early design which is still in production. The head *A* with its integral ring-belt *B* is isolated from the skirt *C* by the transverse slot *D* in the lower ring-groove. This groove is provided with an oil-control ring to remove the excess of oil from the cylinder-wall. The struts *E* transmit the gas pressure from the head to the piston-pin bosses *F* and, owing to their juxtaposition to the connecting-rod, exert a very small bending-moment upon the pin. Incidentally, they relieve the ring belt and the skirt of all direct compressive stresses.

Steel control bands *G* and the compensating slot *H* limit the thermal expansion of the skirt to that of the bands. These circular bands, being cast into the skirt, are snugly embedded in the aluminum but are not bonded thereto. Their coefficient of thermal expansion is about half that of aluminum. Since the skirt and the bands have the same temperature, the aluminum shell expands twice as much as the steel and reduces the width of the compensating slot. As this slot is formed by a sheet-metal splitting-core when the piston is poured, it cannot close at any temperature the piston may encounter.

Thermal advantages accruing from the use of the struts are no less real than the mechanical gains. In Fig. 1, the broken line *I* traces the path of the heat absorbed from the gas by the central zone of the head. The line *J* shows the route of the heat acquired by the outer zone. Both zones conduct the heat radially outward but the paths do not coincide at any point. Between these two areas is an intermediate annulus in which the heat flows radially inward as indicated by the line *K*. The heat from the central and the intermediate zones, therefore, is conducted through the struts directly to the skirt. No section of the head conducts a large portion of the heat radially. The result is a head of almost uniform temperature instead of one with a cool periphery and a hot spot in the center.

The relative temperature conditions in a shell-type piston and a strut-type piston are shown graphically by the computed temperature curves in Fig. 2 respectively. Both pistons are assumed to be operating with their heads exposed to gases of the same temperature and with their coefficients of heat absorption, conduction, and emission identical. The volume of metal required to make the piston operate at these temperatures is taken as an index of the suitability of the design.

In the shell type, every annular section of the head conducts radially all the heat absorbed by the exposed area enclosed by that section. The metal at 1-in. radius conducts the heat that has entered the central circular area 2 in. in diameter. The section at 2-in. radius conducts the heat absorbed by an area four times as great. Unless the conducting sectional area increases with the thermal flux, the temperature gradient, which causes the flow of heat, must become progressively greater as

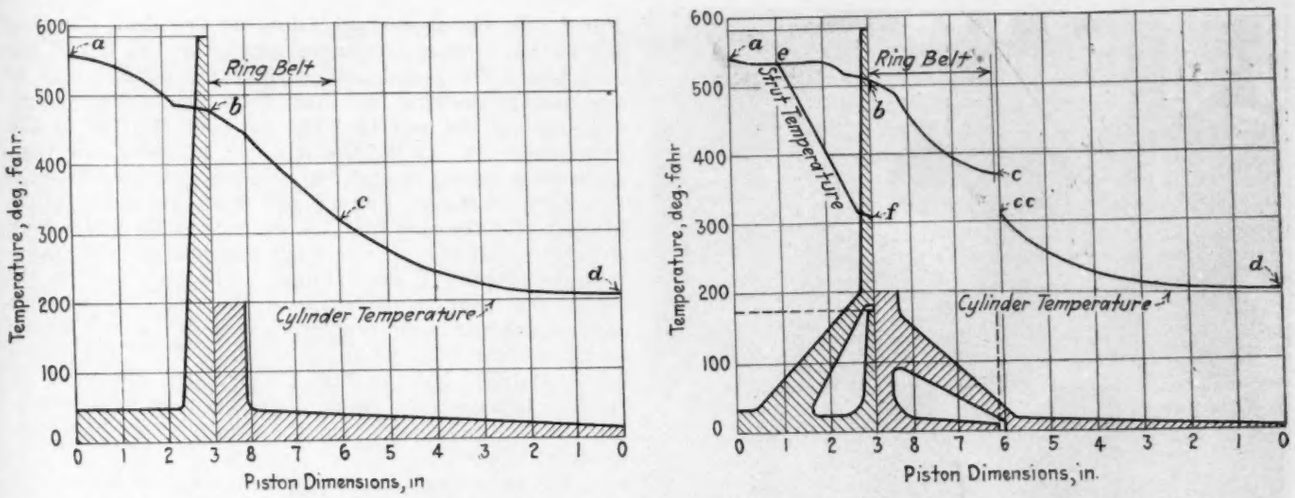


FIG. 2—COMPARATIVE TEMPERATURE CONDITIONS IN SHELL-TYPE AND STRUT-TYPE PISTONS

The Diagram at the Left Is for the Shell-Type Piston and That at the Right for the Strut-Type Piston, Both Highly Conventionalized in Form. In Each Diagram, Half Sections of the Piston Are Drawn as Horizontal Scales. Temperatures Obtaining at Various Points in the Piston Are Shown on the Curves, by Reference to the Vertical Scales, Temperatures of Points in the Heads Being Shown at the Left in Each Diagram. For Equivalent Thermal Results, the Strut Type Is Lighter

the periphery of the head is approached. As shown at the left in Fig. 2, the head-temperature curve *a-b* grows steeper with increase in the radius of the section.

In the strut type, the thermal flow, being divided into three parts, can nowhere attain sufficient magnitude to produce a steep gradient. The temperature curve *a-b*, at the right in Fig. 2, is almost flat. The use of struts has the further advantage of improving the rate of heat transfer from the ring belt to the cylinder and thereby leaving less heat to enter the piston skirt. The result is a cooler bearing-surface on the piston and better lubrication.

The reason for this higher thermal-emissivity of the ring belt in the strut-type piston also is evident from

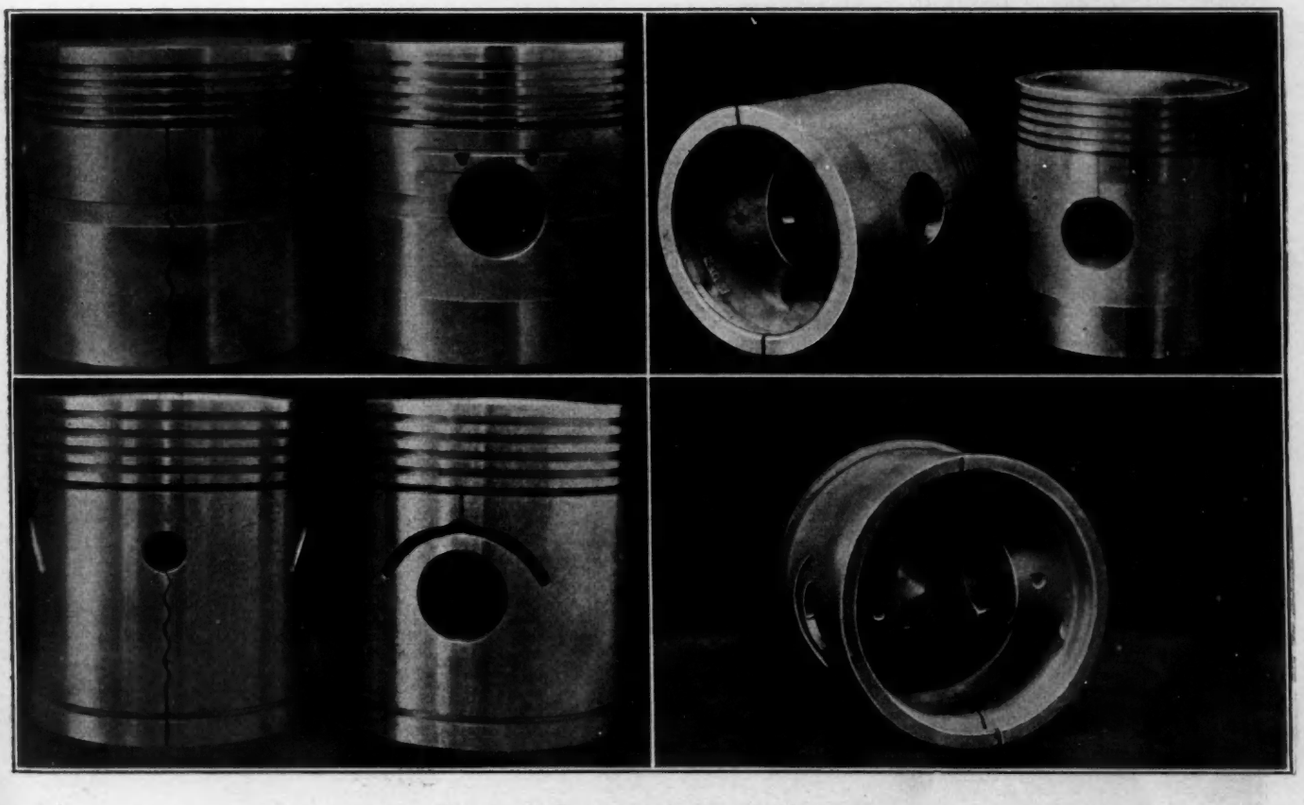


FIG. 3—A GROUP OF ALUMINUM PISTONS

Rail-Car Gasoline-Engine Piston, 7½-In. Diameter

Gasoline-Engine Piston, 7½-In. Diameter, Showing Crescent Slot above Piston-Pin

Flexible Piston with Upper Half of Piston-Pin Boss Severed from Skirt

Piston with Struts Attached to Stepped Piston-Pin Bosses

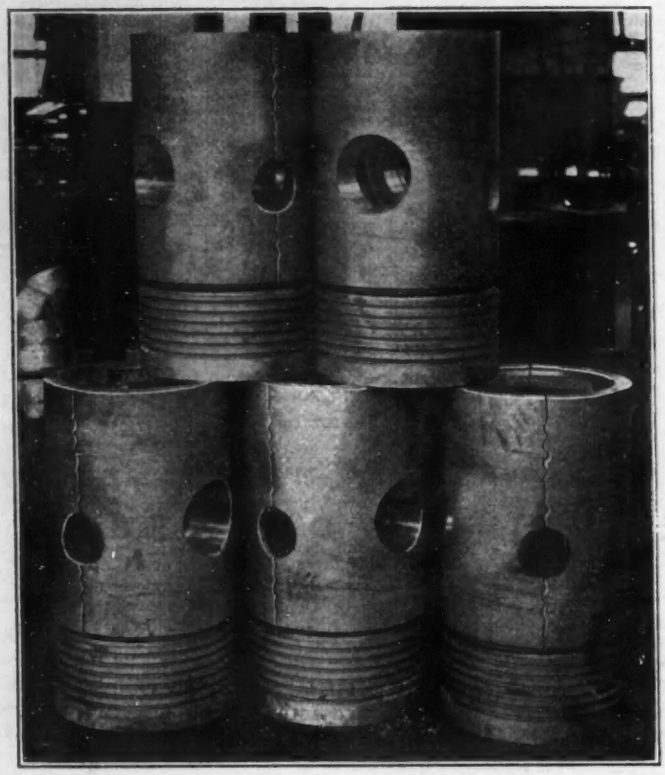


FIG. 4—SEMI-FINISHED PISTONS FOR DIESEL ENGINE

These 16½-In. Diameter Pistons Are Characteristic of Those Made for Large Diesel Engines. They Were Used in the Engine Shown in Fig. 5. Similar Pistons Were Built into a 16½ x 26-In. Engine That Operates 24 Hr. per Day on a Dredge

Fig 2. In the shell-type piston, all the heat absorbed by the head enters the barrel section at the top of the ring belt. The metal behind the compression rings at any part of the ring belt must therefore conduct longitudinally all the heat that has not been emitted by the rings above it. If the thermal flux is heavy, the temperature gradient is high; in other words, the temperature curve is steep. For a given maximum temperature at the top of the ring belt, the average temperature over the entire belt is low, with a correspondingly low transfer-rate of heat to the cylinder. The only way to increase the mean temperature of the ring belt without raising the maximum temperature is by using a heavy barrel section to improve its conductivity. The curve *b-c* in the left half of Fig. 2 illustrates the effect of thermal flux upon the temperature gradient in the shell-type piston, and shows that the average ring-belt temperature is low.

In the strut-type piston, only as much heat enters the ring belt as can be emitted therefrom, since no heat is conducted across the transverse slot. Of course, the temperature gradient is nil at the slot, and never becomes excessive at any part of the curve. The temperature is, therefore, nearly uniform, giving a rapid emission of heat from all parts of the belt.

The curves *c-d* and *cc-d* in Fig. 2 are the skirt temperature, which has nearly the same maximum value in both cases. The thermal distortion of the skirt in both pistons should therefore be practically identical. The skirt of the shell-type piston is distorted mechanically by the expansion of the ring belt and the skirt of the strut-type is distorted by the struts. Owing to the smaller mean radius, the struts expand less than the ring belt in a radial direction and so have less tendency

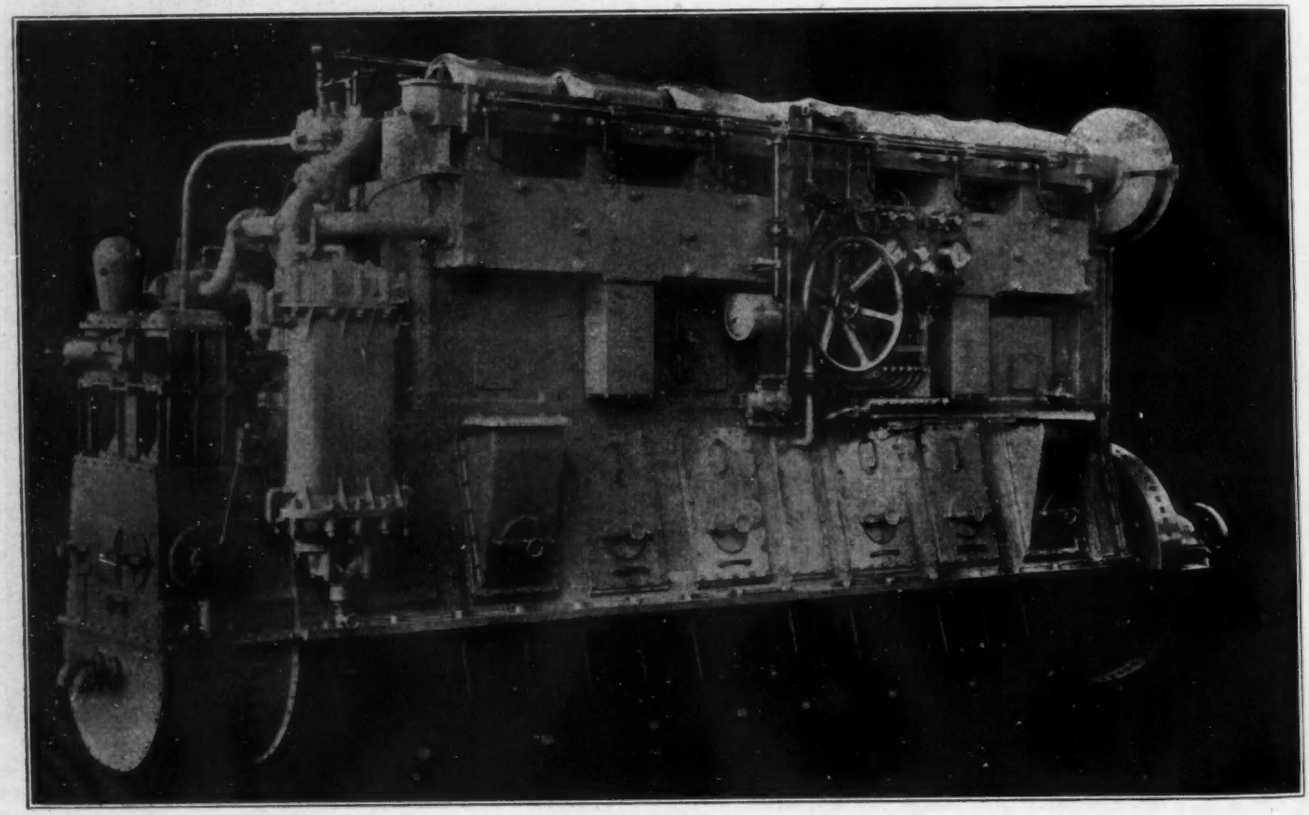


FIG. 5—WINTON DIESEL-ENGINE, 800 HP.

Two of These Six-Cylinder 16½ x 22-In. Engines Propel a 188-Ft. Yacht with 27½-Ft. Beam and 10½-Ft. Draft

to deform the skirt. The total distortion of the bearing surfaces therefore probably is lower in the strut-type than in the shell-type piston.

These two pistons, which are highly conventionalized for mathematical simplicity, have been analyzed purely as thermal conductors and dissipators. Symmetrical about their vertical axes, without rings and piston-pin bosses, they represent their respective types reduced to the simplest terms. In this condition, the shell-type piston contains one-third more material than the strut-type piston. Granting that both pistons will require the same volume of metal in the bosses, the advantage still lies overwhelmingly with the strut type. As a matter of fact, the shell-type piston will need larger bosses, reinforced with ribs, to be equivalent mechanically to the strut type.

It is evident, then, that the strut-type piston is the more economical in metal. The proportionate saving will vary somewhat with the choice of operating conditions, but the foregoing results are typical of the general conclusions drawn from a rather extensive series of such mathematical investigations.

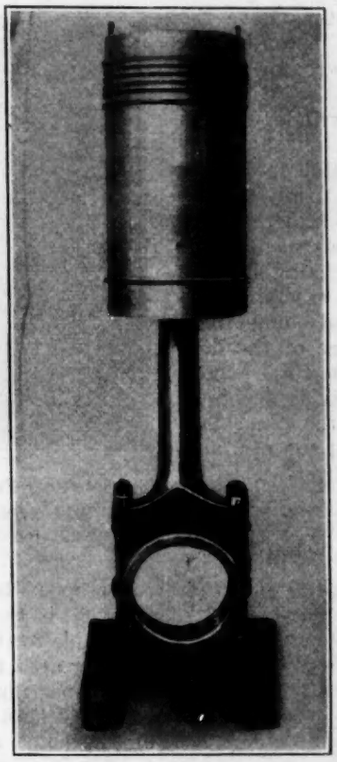


FIG. 6—LARGE PISTON AND CONNECTING-ROD ASSEMBLY

This 18-In. Piston Is Used in a 1500-Hp. Eight Cylinder Engine. The Plug in the End of the Piston-Pin Prevents Contact between the Pin and the Cylinder-Wall and Contributes to Oil Economy

SOME ALLOY PISTONS IN SERVICE

A few examples of Bu-Nite pistons in present use illustrate various modifications of the early design in Fig. 1. The piston shown at the upper left in Fig. 3 is used in a gasoline rail-car engine of 7½-in. bore. It is representative of the pistons of this make manufactured for large, heavy-duty gasoline engines. The piston-pin, 30 per cent as large in diameter as the piston, has a free bearing in the piston-boss, which is lubricated by the oil thrown from the crank-pin and scraped from the cylinder-wall. The aluminum alloy, after a short running period, develops a satisfactory wearing surface that is continually improved by the carbon from the lubricating oil.

Pistons like those seen rough-finished in Fig. 4 were installed in the 16½ x 22-in. 800-hp. Winton Diesel-engine shown in Fig. 5. They illustrate the general proportions of pistons in their class. A pair of the engines of Fig. 5 furnishes the motive power for a yacht 188 ft. long with 27½-ft. beam and 10½-ft. draft. Similar pistons are used in a 16½ x 26-in. engine for a dredge that operates 24 hr. per day, 7 days per week, with a lubricating-oil consumption of 4 gal. per day. The performance is about 975 i.hp. at 225 r.p.m., or 103 lb. indicated mean effective pressure.

A still larger piston, shown assembled with its connecting-rod in Fig. 6, conveys some idea of the rugged design that characterizes the eight-cylinder Bessemer engine in which it is used. The 18-in. diameter piston has an 8⅞-in. piston-pin and drives a crankshaft 12¾ in. in diameter. The engine develops 1500 b.hp. at 300 r.p.m. and is remarkably free from vibration. A pair of these engines is to be installed in one of the largest Diesel-engine yachts in the world with an over-all length of 294 ft.

The pistons illustrated thus far have full circular skirts, broken only by the longitudinal compensating-slots and, in some cases, by an orifice for a wrench to tighten the piston-pin lock-bolt. The large piston-pin bosses are bushed to conform with marine regulations, but the bushings are composed of the same alloy as the pistons. The larger pistons are provided with Bu-Nite caps at the ends of the piston-pins, as seen in Fig. 6, to retain the lubricating oil with which the pins are flooded. These piston-pin closures, which guard the cylinder against excessive lubrication, are important factors in the excellent oil economy of the engine shown in Fig. 5.

DESGN MODIFICATIONS

Some variations from the simple skirt designs of the foregoing pistons are shown in the piston illustrated in the lower left part of Fig. 3. This is a gasoline rail-car piston of the same diameter as the piston shown above it. The distinctive features are the crescent-shaped slot above the piston-pin boss and the divided compensating slot. The crescent opening increases the flexibility of the skirt and permits the upper control-band to function more effectively. The improvement in the control is especially evident in a piston with a short compression. In this piston the crescent cut is formed by the main core, whereas the only practical method of casting the slot in a short-compression piston is by a core applied externally.

In Fig. 7 is shown a 16-in. piston in the rough and the assembly of dry-sand core and steel control-bands and splitting-strips used in casting it. When the core is thus assembled and lowered into the gray-iron die, the casting may be poured. All pistons, regardless of size, are cast in metal dies. The die for an 18-in. piston 38 in. long weighs 1800 lb. and assists effectively in chilling the 600 lb. of aluminum alloy that forms the rough casting Separate chills are used within the core to improve the texture of the struts.

A further modification of the flexible-skirt piston is illustrated in the upper right view of Fig. 3. The outer surface is continuous except for the compensating slots, but the skirt is separated from the upper half of the piston-pin bosses by a cored slot inside the piston. This design assists materially in maintaining a circular skirt and is the most effective method yet found for preventing distortion in a piston that is designed with an exceptionally short compression.

PISTON-PIN DESIGN INFLUENCED BY STRUTS

The use of struts to connect the head to the bosses is commendable, both mechanically and thermally, for producing a piston that is to be subjected to heavy pressure and high temperature. The strut-type piston is not so adaptable in design, however, as the shell type. To provide space for the struts, the bosses must extend reasonably close to the center of the piston, limiting the length of the bearing in the upper end of the con-

necting-rod. For this reason, many pistons have the free bearing for the piston-pin in the piston-bosses. The pin may be clamped in the connecting-rod or it may float in both rod and piston.

If a floating piston-pin is used, the cylinder-wall is protected from abrasion either by caps, as shown in Fig. 6, or thrust plugs, like those illustrated in Fig. 8, The latter consists of a tubular steel pilot firmly bonded to a Bu-Nite disc. The pilot fits snugly into the bore of the piston-pin and, owing to its ferrous nature, remains tight at all temperatures. The disc, being slightly smaller in diameter than the pin, permits assembly and disassembly of the piston, piston-pin, and connecting-rod without tools. The radius of the face of the disc is the same as that of the cylinder, and the total length of the thrust plug and piston-pin assembly is designed to allow some longitudinal movement of the pin. The result is uniform wear over the surface of the pin, and absence of circumferential scratches from possible abrasives in the lubricant.

If the load on the piston is exceptionally heavy, or if the piston-pin must be anchored in the piston-bosses,

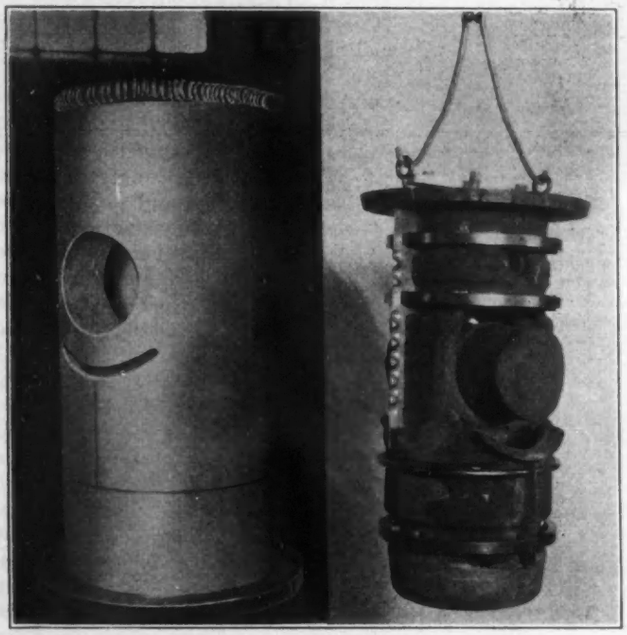


FIG. 7—A LARGE PISTON AND ITS CORE

At the Left Is Shown a Rough-Turned 16-In. Piston for a Diesel Engine. At the Right Is the Core Used in Casting the Same Piston, with the Four Expansion-Control Rings and the Metal Inserts for Producing the Slits. The Pistons Are Cast in Metal Pots

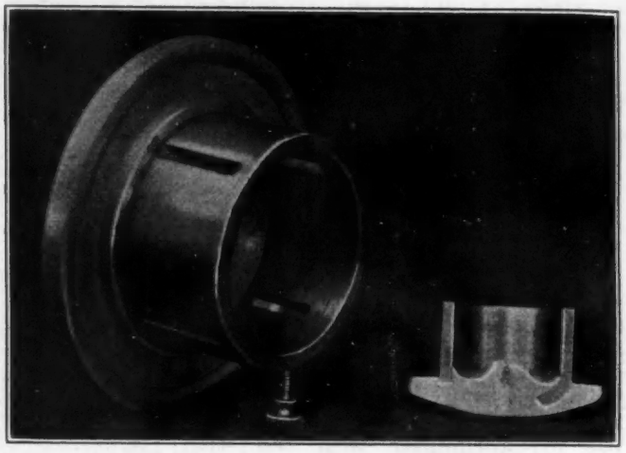


FIG. 8—COMPOSITE THRUST PLUGS

These Piston-Pin Plugs Are Made Up with Steel-Tube Pilots, Split for Flexibility, and Cast Aluminum-Alloy Discs

the stepped boss, shown at the lower right corner of Fig. 3, is sometimes adopted. This construction is favorable to the strut design and presents the maximum bearing area to the heaviest load in both the piston and the connecting-rod. The unit bearing pressures, therefore, are kept within reasonable limits. The only load on the short steps of the bearings is that due to the inertia force of the reciprocating parts at the head end of the stroke, and in two-cycle Diesel engines even this load is absent.

LARGE-PISTON FIELD INCREASING

The service records of the pistons presented herein show that aluminum-alloy pistons are practicable in large, heavy-duty engines. They have eliminated the necessity for indirect cooling of the pistons in diameters up to 18 in., and the limit probably has not been reached yet. Pistons of this type have progressed beyond the experimental stage, although new developments in design and manufacture are being introduced as special conditions may dictate. No attempt is made to predict the ultimate design in aluminum-alloy pistons for very large engines, but experience has proved beyond a doubt that the performance of large gasoline engines and of moderate-size Diesel engines is improved by the use of the alloy piston. As the demand for a high power-to-weight ratio grows in the Diesel engine industry, as it has in the automotive gasoline engine industry, the aluminum-alloy piston will be accepted eventually as the heart of the engine.

Treating Gasoline

A LARGE part of the gasoline production was formerly treated with strong sulphuric acid for the primary purposes of improving the color and odor of the product and of eliminating gummy impurities. The difficulty with the sulphuric-acid treatment is that it not only removes the objectionable bodies but also attacks the unsaturated compounds such as the olefins. These compounds are not only harmless but, on the contrary, have been shown to be highly desirable. Attempts to supplant the treatment with strong sulphuric acid, with its consequent high loss amounting frequently to several per cent, have resulted in numerous processes. These include dilute-acid treatment, acid treatment at low temperatures and a process of treatment with fuller's earth in the vapor phase. It is claimed that by the fuller's-earth treatment the objectionable impurities are removed with a treating loss amounting to only a few tenths of 1 per cent and an important resultant saving. This general problem is still an active subject of petroleum research.—J. B. Hill, in *Industrial and Engineering Chemistry*.

Protective Value of Chromium-Plate

By EDWIN M. BAKER[1] AND WALTER L. PINNER[2]

ANNUAL MEETING PAPER *Illustrated with* CHART AND PHOTOGRAPH

This paper is restricted in scope to a study of the rust resistance afforded by electrodeposited coatings of chromium alone and in combination with nickel and copper.

The appearance value of a chromium surface is well established; but chromium alone has little protective value for outdoor exposure.

The protective value of a composite coating depends largely on the protection afforded by the underlying coats.

Increase in the amount of chromium deposited on nickel and copper, up to a thickness of 0.00001 to 0.00002 in., increases the protective value, but a further increase of thickness up to 0.00027 in. of chromium decreases the protective value to almost the result obtained with no chromium.

These conclusions are supported by data presented in tabular and graphic forms, and indicate the proper procedures to obtain maximum protective value at minimum cost.

IN the electroplating field, no subject has created more widespread interest than chromium deposition. This subject is of particular interest to the automotive engineer, who is employing chromium for two somewhat different purposes. One of these is the coating of surfaces to resist wear. The other is the electrodeposition of chromium for decorative and protective purposes. The thickness of deposits suitable for these two purposes is so widely different as to justify separate consideration of these two applications. It is the purpose of this paper to present the results of a research upon the protective value of chromium-plating when applied alone and when applied in combination with electrodeposited copper and nickel.

The ability of chromium to resist atmospheric corrosion or tarnishing has been well established and its characteristics in this regard are so well known as not to require further discussion. A sales point of no little value is embodied in a car equipped with a chromium-plated radiator shell, head-lamps, bumpers, door handles, locks and other hardware. To the user it is a source of pride to drive such a car, and also a source of comfort to know that no continual polishing is required to maintain a pleasing luster on these plated parts. Tarnish resistance of chromium, however, means nothing unless the coating as a whole is so constituted as to afford adequate protection against corrosion of the underlying steel.

The hardness of chromium and its resistance to scratching are also well known, and little difference of opinion exists so long as discussion centers about deposits of considerable thickness. There has been some tendency to convey the idea, at least by implication, that chromium, applied for protective or decorative purposes, would lend to an article considerable resistance to abrasion. As will be shown later, the thickness of chromium deposited for decorative purposes is usually well under 1 micron, and, regardless of the intrinsic hardness of chromium, such a thin deposit upon a softer base-metal cannot well prevent scratching. For decorative purposes then, only three things are to be considered: (*a*) the well-established tarnish resistance of chromium, a quality in which it stands alone in comparison with other electrodeposits; (*b*) the protective value against rusting of the base metal, which is the subject of this paper; and (*c*) the question of cost, which is closely related to the amount of chromium to be deposited upon an article, and on which this paper, therefore, has a bearing.

Two methods were used to test the protective value or quality of the deposits. One was the well-known salt-spray test, conducted as described[3] before this Society by Edwin M. Baker in 1924. The other was the ferricyanide test. In this test a solution containing 10 grams of salt, NaCl, and 1 gram of potassium ferricyanide, $K_3Fe(CN)_6$, in 1 liter of water was used. Paper wet with this solution is carefully spread on the previously cleaned samples. At points where there are holes in the deposit, the sodium chloride aids the electrolytic corrosion of the steel base and the formation of blue spots of ferro-ferricyanide. After 2 to 5 min. the paper is removed, washed and dried, the blue spots remaining on the paper as a permanent record of the porosity of the deposit. A similar method, using paper impregnated with such a solution containing in addition agar-agar, has been described[4] by Karl Pitschner. Obviously, the smaller the number and size of these spots are, the better is the protective value of the deposit, but the relationship may not be quantitative.

[1] Assistant professor of chemical engineering, University of Michigan, Ann Arbor, Mich.

[2] C. G. Spring & Bumper Co., Detroit.

[3] See THE JOURNAL, February, 1927, p. 127.

[4] See Preprint 38, Proceedings of the American Society for Testing Materials, June, 1927.

Pieces of steel about 3/16 in. thick by 1½ in. wide by 5 in. long, polished on both sides, were used as the base of all deposits. Two ½-in. square holes were punched in these pieces. Cathodes of this form were chosen because they have been found to give results that agree with production plating much more closely than results obtained with simple flat panels.

The nickel-plating solution used was a modified Watt's bath[4] containing nickel sulphate, nickel chloride, and boric acid. Copper-plating on nickel was done in an acid-copper-sulphate bath[5], and on steel in a copper-cyanide bath[7].

A Sargent chromium-plating bath, containing 200 grams of chromic acid, CrO_3, and 3 grams of chromium sulphate, $Cr_2(SO_4)_3.18H_2O$ per liter, was used. This was operated at 100 deg. fahr., at a cathode current density of 100 amp. per sq. ft., and with lead anodes.

The steel specimens were plated with various thicknesses of nickel, copper and chromium. These thicknesses were not measured directly but were calculated in each case from the current density, the time of plating, and the cathode current efficiency. Table 1 shows the relation between thickness of deposit and the number of ampere-minutes of electricity used per square foot of surface plated, at the respective cathode current efficiencies. For convenience, thicknesses of deposits will be given in terms of the "ampere-minutes per square foot of surface plated", and this quoted phrase will be implied rather than stated.

The combinations of plating used on the specimens were as follows. The specimens for Series I were made of S.A.E. 1095 Steel, while all the other specimens were made of S.A.E. 1010 Steel.

Plating Combinations Employed

Series I—Chromium, 50 to 15,000
Series II—Chromium, 50 to 15,000
Series III—Chromium, 300, on nickel 50 to 1000
Series IV—Chromium in thicknesses varied from 0 to 6000, over nickel 300
Series V—Chromium in thicknesses varied from 0 to 6000, over "cyanide" copper 345[8]
Series VI—Chromium in thicknesses varied from 0 to 6000, over a base deposit of nickel 200, "acid" copper 300
Series VII—Chromium in thicknesses varied from 0 to 6000, over a base deposit of nickel 100, "acid" copper 100, nickel 300
Series VIII—Chromium in thicknesses varied from 0 to 6000, over a base deposit of nickel 200, copper 300, nickel 400

All specimens that were plated with either nickel or copper were buffed before being chromium-plated. After buffing, a ferricyanide test was made on one side of these specimens, and the ferricyanide test was repeated on this same side after chromium-plating. The reverse side was tested in the salt spray. In the case of Series I and II, where chromium was deposited directly on steel, one side of each specimen was tested in the ferricyanide test and the other in the salt spray. The results of the salt-spray tests are presented in Tables 2 and 3 and in Fig. 1. The time shown for the duration of the salt-spray test is the number of hours required for the specimen to become very noticeably rusted. This stage was considered to be reached when rust could be clearly discerned when the piece was held in a favorable light at arm's length.

Tabulated data and charts are not given for the ferricyanide tests, as the data were so erratic that their publication in detail hardly seems justified. These tests, however, did furnish some information.

TABLE 1—RELATION OF THICKNESS OF DEPOSIT TO AMPERE-MINUTES OF ELECTRICITY REQUIRED PER SQUARE FOOT PLATED

Ampere-Minutes per Sq. Ft.	Nickel	Copper from Acid Bath	Copper from Cyanide Bath[8]	Chromium[9]
100	0.000088	0.000094	0.000084	0.00000438
200	0.000176	0.000187	0.000167	0.00000878
300	0.000264	0.000281	0.000251	0.0000131
345	0.000303	0.000323	0.000288	0.0000151
400	0.000352	0.000374	0.000334	0.0000175
500	0.000440	0.000468	0.000418	0.0000219
600	0.000528	0.000561	0.000501	0.0000262
700	0.000616	0.000655	0.000585	0.0000306
800	0.000704	0.000748	0.000668	0.0000350
900	0.000792	0.000842	0.000752	0.0000394
1,000	0.000880	0.000935	0.000835	0.0000438
1,500	0.00132	0.00140	0.00125	0.0000657
3,000	0.00264	0.00281	0.00251	0.000131
4,500	0.00396	0.00421	0.00376	0.000197
6,000	0.00528	0.00561	0.00501	0.000263
7,500	0.00660	0.00701	0.00626	0.000329
9,000	0.00792	0.00842	0.00752	0.000394
10,500	0.00924	0.00982	0.00878	0.000460
12,000	0.0106	0.0112	0.0100	0.000526
13,500	0.0119	0.0126	0.0113	0.000591
15,000	0.0132	0.0140	0.0125	0.000657

[8] Cathode efficiency, 44.7 per cent.
[9] Cathode efficiency, 13.3 per cent.

Discussion of Results Obtained

In general, the ferricyanide test shows that improved protective value is obtained by chromium-plating. The results are less erratic and improvement is more uniformly obtained when the thickness of chromium lies between 250 and 600, although much depends upon the

TABLE 2—RESULTS OF SALT-SPRAY TESTS ON VARIOUS THICKNESSES OF CHROMIUM

Thickness of Chromium, Amp-Min. per Sq. Ft.	Time in Salt Spray Required to Reach Very Noticeably Rusted Stage, Hr. Series I	Series II	Series IV	Series V	Series VI	Series VII	Series VIII
None	..	..	64	24	24	56	144
50	8	4	136	24	24	88	184
100	8	4	96	24	24	72	144
150	8	4	144	24	48	96	360
200	8	8	144	24	40	112	192
250	8	8	144	24	40	272	272
300	8	8	48	24	24	120	232
350	8	8	96	24	64	88	232
400	8	8	144	24	48	136	264
450	8	8	144	24	48	208	368
500	8	8	128	24	48	168	304
550	8	8	128	24	48	128	368
600	8	8	104	24	48	112	264
1,500	8	40	144	24	48	88	64
3,000	8	40	256	16	48	128	96
4,500	8	40	192	16	48	232	72
6,000	8	40	256	16	48	88	96
7,500	8	24					
9,000	8	24					
10,500	8	48					
12,000	8	64					
13,500	8	48					
15,000	8	56					

[4] See Principles of Electroplating and Electroforming, by Blum and Hagaboom, p. 236.
[5] See Principles of Electroplating and Electroforming, by Blum and Hagaboom, p. 196.
[7] See Principles of Electroplating and Electroforming, by Blum and Hagaboom, p. 208.
[8] "Cyanide" copper 345 was approximately equivalent in thickness to "acid" copper 300 or nickel 300.

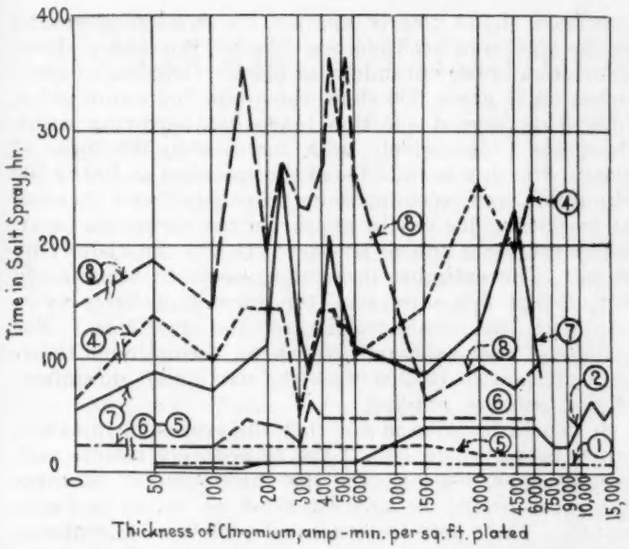


FIG. 1—RESULTS OF SALT-SPRAY TEST OF CHROMIUM-PLATE

Duration of the Test Is Given in Number of Hours in the Salt Spray Required for the Specimen to Become Very Noticeably Rusted. Thickness of the Chromium-Plate Is Given in Ampere-Minutes of Electric Current Used per Square Foot of Surface Plated. Figures in Circles Indicate the Series of Plating Combinations Employed. It Will Be Noted that in General the Lines Do Not Cross One Another. The Highest Resistance to the Salt Spray Is Indicated for Series VIII, Chromium-Plating of 150 to 550 Thickness, in Ampere-Minutes, over a Base Deposit of Nickel 200, Copper 300, and Nickel 400

quality and the nature of the underlying deposits, and possibly on the chromium-plating conditions. Less marked but more definitely uniform improvement is indicated particularly for deposits in which a heavy coat of nickel underlies the chromium.

The specimens of Series V, in which the base coating was "cyanide" copper, actually show a poorer ferricyanide test after chromium-plating, unless the thickness of chromium is greater than 1000. This is thought to be due to the solvent action of the chromium-plating solution on the copper, which may conceivably be very thin in certain spots where the copper-plate, or copper buffing, had just barely closed some pores in the copper deposit.

When chromium alone was plated on steel, Series I and II, the plate on low-carbon steel was much less porous than the plate on high-carbon steel; and in the latter case, for all thicknesses of chromium used, the pores in the deposit were so numerous that the test piece was completely covered with a fine blue smudge.

The data on salt-spray tests are somewhat erratic but nevertheless point rather definitely to certain conclusions. More consistent data would be obtained if simple panels were used on which to plate, but the results would then be less closely related to practice.

TABLE 3—RESULTS OF SALT-SPRAY TESTS ON VARIOUS THICKNESSES OF NICKEL UNDER CONSTANT CHROMIUM-THICKNESS

Thickness of Nickel, Amp.-Min. per Sq. Ft.	Time in Salt Spray, Hr. Series III
0	8
50	40
100	40
150	72
200	72
250	72
300	40
350	216
400	208
450	264
500	48
550	208
600	360
650	360
700	40
750	40
800	208
850	208
900	96
950	392
1,000	120

BASE PLATE LARGELY DETERMINES PROTECTIVE VALUE

It will be noted first of all from Fig. 1 that, in general, the curves do not cross one another. Clearly, therefore, the protective value of the base plate largely

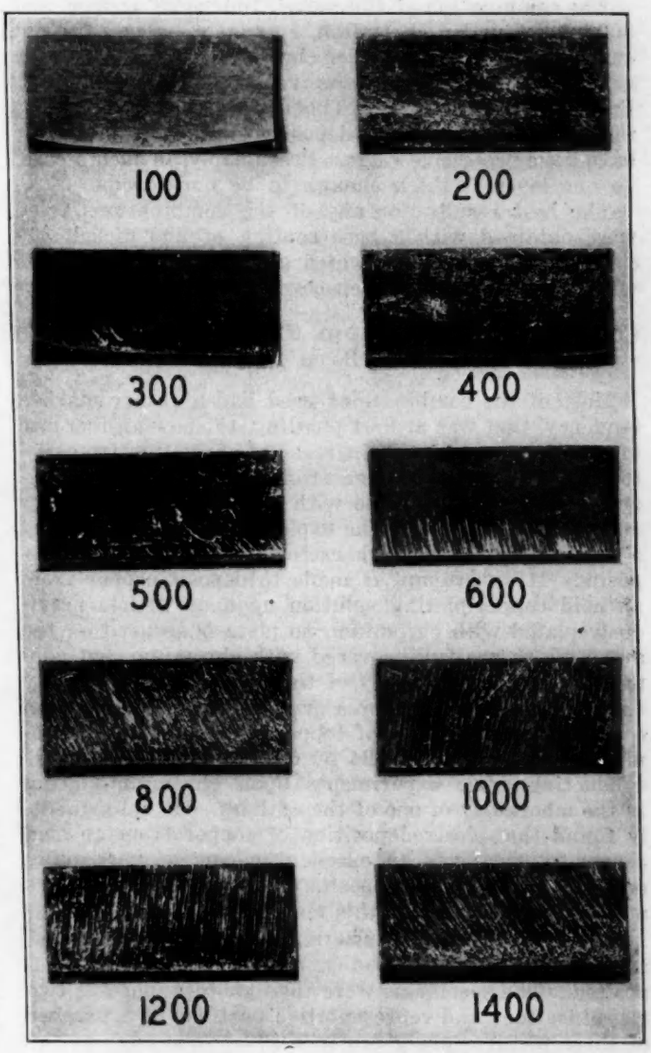


FIG. 2—NICKELED SPECIMENS PLATED WITH CHROMIUM AND THEN WITH COPPER

These Photographs Are Representative Portions of Micrographs at Two Diameters of Specimens Plated with Various Thicknesses of Chromium As Indicated in Numbers of Ampere-Minutes of Current Required To Plate 1 Sq. Ft. The Edge of Each Specimen Shows against the Black Background at the Bottom of Each Picture. Above This the Copper Shows as White and the Chromium as Black. Chromium Deposits up to about 300 Show Numerous Fine Round Pores, While for Greater Thicknesses Fine Cracks in the Chromium Layer Start at the Lower Edge and Become More Pronounced with Increase in Thickness. Optimum Protection Seems To Be Afforded by a Chromium Thickness of 300 to 600

determines the relative protective value, after chromium-plating, for equal thicknesses of chromium-plating. This is further borne out by the data of Table 3 for Series III.

Chromium has little protective value for outdoor exposure when applied directly to steel, within the range of thickness covered by these experiments, when compared with the protective value that might be obtained for the same cost if combination coatings were used.

Copper under chromium is inferior to the same thickness of nickel under chromium, and, in fact, in thickness up to 0.0003 in. the combination has little to recommend it. A base coating consisting of 200 nickel and 300 "acid" copper likewise gives disappointingly low results.

The combination of 100 nickel, 100 "acid" copper, and 300 nickel under chromium, strangely enough, is not superior to 300 nickel under chromium. This agrees, in general, with some results reported[10] by Edwin M. Baker and by Blum and Thomas[11], which also indicate that very thin alternate deposits of nickel and copper have little protective value. Presumably, in such a case, no one layer is thick enough to be non-porous.

The best results for any of the combinations tried were obtained with a base coating of 200 nickel, 300 copper, and 400 nickel, which gives the highest values when used alone and when covered with chromium.

Copper Does Not Deposit on Chromium from an Acid Bath

Most of the combinations used had a rather marked tendency, that was at first puzzling, to show an increase of protective value with increase of chromium from 100 to about 300, little change from 300 to 600, and a decrease in protective value with further increase in the amount of chromium. The explanation was found after a further study of the characteristics of chromium deposits. If an attempt is made to deposit copper from an acid copper-plating solution upon an article previously plated with chromium, no plate is secured on the areas which are fully covered with chromium, but copper is deposited upon any of the base metal which may show through minute pores or cracks in the chromium covering. This failure of copper to deposit upon chromium was noticed in 1924 by George Dubpernell when conducting some experiments upon chromium-plating in the laboratory of one of the authors. He subsequently found that electrodeposition of copper from an acid copper-solution was an excellent means of portraying porosity in chromium deposits, and the present authors are indebted to him for this method of portrayal.

Nickel-plated specimens were coated with various amounts of chromium, and copper was subsequently deposited. The specimens were then photographed at two magnifications and representative portions of a number of these pictures are given in Fig. 2. The edge of the specimen shows clearly against the black background at the bottom of each picture. Above, the copper shows as white and the chromium as black. Deposits of chromium up to about 300 show numerous fine round pores, indicating beyond question inadequate covering which decreases progressively with increase in thickness of plate. Starting at the edge of the specimen at 400 or 500 chromium, and becoming more pronounced with increase of thickness, fine cracks appear in the chromium layer, which therefore affords less protection to the underlying metal. The optimum protection seems to be obtained with 300 to 600 chromium, the amount probably varying with the configuration of the specimen. For articles of reasonably uniform shape, the optimum thickness appears to be 300 with the particular chromium-plating solution studied.

It should be pointed out that the cracks in the chromium portrayed in Fig. 2 are exceedingly minute and, before copper-plating over the chromium, all of these specimens would be characterized as being perfectly plated. These minute cracks should not be confused with coarse cracking associated with non-adherent deposits of chromium. It is believed that the microscopic cracks are characteristic of chromium deposited from chromic-acid solutions. Our view on this point is confirmed by private communications from a number of other laboratories. Change of chromium-plating conditions, however, may vary the optimum amount of chromium for minimum porosity. It is planned to present the results of a research upon these variables at some later time.

Base Plating Determines Rust-Resisting Value

Chromium-plating, correctly used, should be of great value in producing tarnish-resistant and rust-resistant articles having a steel base. Neither producer nor consumer, however, should be led to have false confidence in this "wonder metal". Its value depends upon the skill with which it is employed, and uniformly satisfactory results will come only from correct plant procedures and accurate control.

A correct plant procedure will involve, first of all, proper preparation of the steel to receive base coatings, as otherwise subsequent chromium-plating will cause the base plate to be non-adherent. The base plate should be of sufficient thickness and of proper quality to itself impart considerable protective value. The chromium subsequently applied should be reasonably uniform over all portions of the article, as otherwise some portions will have less and other portions more than the optimum amount of plate. Chromium-plating baths possess notoriously poor throwing power, and this fact serves to emphasize the necessity of the base plate imparting substantially all the protection that is desired to those portions of the article which may not receive an average thickness of chromium-plate. A further step in the correct procedure is the determination, for the particular bath composition and plating conditions used, of the amount of chromium-plate that is required to impart minimum porosity on the particular articles plated.

[10] See THE JOURNAL, February, 1924, p. 130.

[11] See *Transactions of the American Electrochemical Society*, vol. 48, p. 89.

Annual Meeting Paper Corrections

TWO corrections should be made in the paper on Motor Oil Characteristics and Performance at Low Temperatures, by R. E. Wilkin, P. T. Oak and D. P. Barnard, 4th, which was printed in the February, 1928, issue of THE JOURNAL. In the tabulation under Fig. 1 on p. 213, the pour-point of the third oil should be — 5 deg. fahr., not + 5 deg. fahr. In Fig. 9 on p. 218, the viscosity abscissas in Saybolt seconds should read 100 to 1,000,000, not 100 to 100,000; that is, the third logarithmic garden should be numbered 100,000 and the fourth 1,000,000.

Motor-Trucks on the West Coast

By E. C. Wood[1]

Transportation Meeting Paper

LONG-DISTANCE hauling in the four Pacific Coast States has developed a new phase of transportation. Heavy trucks must go where road conditions are not ideal and where grades are steep. These conditions require exceptional performance, involving greater engine power and more transmission speeds than ordinarily. Better control and better brakes are also of vital importance.

At recent meetings of the Northern and the Southern California Sections of the Society, service managers from the larger cities of the State considered automotive engineering from all angles. It was the consensus of opinion that high road-speeds have created the necessity for larger factors of safety and for heat-treated steels, and that these are being used more frequently for this reason. Also it has been noted that the over-drive is demanded in the lighter trucks.

First cost of the vehicle was touched upon both in conference and in communications, and it was felt that the higher initial cost would be justified economically by the greater speeds and by a comparison of cost figures per mile and per ton delivered. The high speed has resulted in necessity for better lubrication, and there seems to be a tendency toward the reduction of chassis weight, especially of unsprung weight.

Long hauls and steep grades, with high speed and some poor roads, make truck operation more severe on the West Coast than elsewhere.

An interesting operation of refrigerator cars and trailers between interior valleys and the coast is described in detail.

Careful routing and dispatching of fleet movements are required to secure economical operation.

The purchase of suitable units now is almost a phase of engineering.

Close contact is needed between designers and operators.

Several States prevent the most efficient use of six-wheel vehicles by limiting the six-wheel truck to the same maximum load as the four-wheel vehicle, in spite of the fact that the weight distribution of the former results in less damage to the roadway. The use of these vehicles, with the advantages that might accrue, thus is discouraged.

The Arizona-California Transportation Co., operating an intercity trucking service from Los Angeles to Yuma and Phoenix, Ariz., has equipped one of its large six-wheel trucks with eight large pneumatic tires on the wheels and one spare tire. This truck runs regularly between the three cities, carrying about 8 tons per trip and making the 500-mile run in about 30 hr.

Refrigerator Cars on the Road

An interesting operation which is quite new on the Coast is the use of iceless-refrigerator cold-storage motor-trucks over long distances for the handling of butter, eggs, meat and other perishables to coastwise markets from their points of origin in the hot interior valleys. This service has been established by the Golden Gate Motor Transportation Co., of San Francisco, a subsidiary of the Golden Gate Ferry Co.

Two such units have been installed, each consisting of a six-wheel truck with van body and a six-wheel trailer, also with van body. The combined capacity of each unit is 21 tons. Twelve-hour schedules are maintained as far north as Redding, Cal., and as far south as Merced, Cal., penetrating the heart of the Sacramento and San Joaquin valleys. The longest run is from San Francisco to Redding, 125 miles, and return. General merchandise is carried from San Francisco to the communities in the hot interior valleys and perishable products of the farms, poultry ranches, dairies and orchards are brought back. Though installed only in June, 1927, capacity cargoes in both directions have been offered for both units on every trip, after the first experimental tour of the valleys was made.

A third unit, consisting of truck and trailer exactly similar to the other two units, is now under construction and plans are well under way for extension of the service southward to Fresno, 55 miles further down the San Joaquin Valley, and for another route between Merced and San Francisco around the lower end of San Francisco Bay.

All three of the cold-storage trucks were designed and built by the Fageol Motors Co., of Oakland. They are 10-66 models, with four dual wheels at the rear and two single wheels in front, rated at 10 tons and equipped with six-cylinder 120-hp. engines. The trailers, almost as large as the trucks, are also of the 10-tire type, designed and built by the Reliance Truck & Trailer Co., Inc. Westinghouse air-brakes operate from the driver's seat on both truck and trailer, with compressed air provided by an auxiliary gas-engine-generator plant, which also supplies lights for the exterior and interior of truck and trailer and current for the motor of the Kelvinator refrigerating plant.

An Auxiliary Powerplant Carried

This auxiliary powerplant, with the refrigerating unit, occupies a narrow space directly back of the driver's seat, completely insulated as to heat or cold from the cargo box of the truck. The van bodies of both truck and trailer are floored, walled and ceiled with 6 in. of insulating material. The auxiliary machinery is automatically controlled, the Kelvinator being regulated by a thermostat, so that the inside temperature is automatically maintained at 34 deg. So long as this

[1] M.S.A.E. — Superintendent of transportation, Pacific Gas & Electric Co., San Francisco.

temperature is maintained, a green light glows beside the driver's seat. When the interior temperature either increases or decreases, the change is indicated by a flashing red light so placed that it cannot escape the driver's attention. Thermostatic control over the Kelvinator, however, automatically holds the temperature to the 34-deg. standard.

The interior of the truck body resembles a cold-storage room, with traveling hooks for hanging meat so that the cold air has complete and free circulation around it. Other perishables are piled on the floor of the van and carried in the trailer, while both vehicles are used for the return cargoes of general merchandise to the valley towns.

Each of these units of truck and trailer represents an investment of more than $13,000 and the corporation has invested more than $30,000 in this so-far successful experiment with cold-storage transportation by motor-truck. The idea was introduced by C. B. Locklin, who has been operating motor-truck lines for some years in Massachusetts and in California. He interested A. O. Stewart, president of the Golden Gate Ferry Co., and the two organized the Golden Gate Motor Transportation Co., of which Mr. Stewart is president and Mr. Locklin is vice-president and general manager. The Leo J. Meyberg Co.'s San Francisco engineers devised the cooling system for the moving cold-storage house and installed the Kelvinator system.

With the first experimental truck, Mr. Locklin, in the midst of the June heat, went into the Sacramento valley, where temperatures were above 100 deg. all day and much of the night. There he picked up a cargo of butter, eggs, veal and highly perishable fruits and hauled it more than 100 miles to San Francisco during the heat of daytime. It was a moment of some anxiety when the traveling ice-house was opened, but everything was found to be in as perfect condition as when it left the valley. Another unit was built immediately, and the first cold-storage long-distance motor-truck operation is now well established in northern and central California.

Careful Planning Required for Economy

As the operation of motor-vehicles becomes more and more a science, fleet operators are coming to realize that their big problem is how to keep their equipment working; that the best piece of equipment in the world will lose money for them if it is not kept busy. The problems of motor-vehicle operation are problems in the use of time, whether in laying out routes, scheduling and dispatching, or even in the purchase of equipment.

Operating methods are now being studied on the West Coast with the object of keeping the vehicle on the street as well as of reducing the cost of operation. Proper routing and dispatching will enable a piece of equipment to serve the same delivery points with shorter mileage and less wear and tear and will result in capacity loads in both directions.

Formerly trucks generally were sold without regard to the specific requirements of the work they were intended to do, being sometimes of too large capacity and sometimes too small, with unsuitable bodies. Progress in the automotive field has changed these conditions. Automotive manufacturers are beginning to realize that it is to their advantage to build a truck fitted to the business of the prospective buyer. The purchaser is beginning to know what he wants; he has qualified to solve his hauling problem and now is in a position to specify the kind and type of equipment best suited to his work. The purchase of automotive equipment today is almost a phase of engineering.

Some Trucks Modified for Coast Operation

The conditions of topography and climate of the coast section are such that it is not commercial economy to operate ordinary automotive vehicles in that section, as they fail to meet the requirements of durability or of cost per mile. The general standard of design is high but in production the parts have in many cases seemed below the normal in factor of safety. Consequently, the fleet owner is obliged to replace parts, and in some cases to change the design, to uphold the maintenance of the unit and to maintain it within an allowable operating cost.

The automotive engineer at the factory, up to a short time ago, rather resented ideas and suggestions from operators, feeling that most of the operators were guessing. This now has changed and many new developments have come to the engineers from field operators. It is the opinion of operators on the West Coast that there should be closer contact at all times between engineers and operators. If the motor-vehicle manufacturers would stress the contact of their engineers with users as they do contact with the sales department, better results would be obtained.

The outstanding demand in the commercial field today is reduction of weight, to give the operator the advantage of hauling a larger pay-load with the minimum gross weight and to permit him to move his merchandise in the minimum time.

Charts Transposed in James Paper

IN the paper on Engine and Car Performance, by W. S. James, printed in the January, 1928, issue of THE JOURNAL, p. 96, some of the charts, with their explanatory captions, were inadvertently given wrong figure numbers. To give these in their correct order and to have them agree with references in the text of the paper, the following changes should be made:

Change Fig. 7 to Fig. 4	Change Fig. 4 to Fig. 7
Change Fig. 8 to Fig. 5	Change Fig. 6 to Fig. 8
Change Fig. 9 to Fig. 6	Change Fig. 5 to Fig. 9

Figs. 1 to 3 and 10 to 13, inclusive, were properly designated.

In the text on p. 99, referring to Fig. 4, the rear-axle ratio reading "9.0 to 1" should read "5.0 to 1." The reference to Fig. 6 should read "Fig. 5," as showing that "lower axle-ratio for the same piston-displacement gives lower accelerating-ability." On p. 100 the reference to Fig. 7, showing that the reverse is true of fuel economy, should read "Fig. 6," and on the same page references to Figs. 8, 9 and 10 should read "Figs. 7, 8 and 9."

Improving Engine Performance

By H. M. JACKLIN[1]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DIAGRAMS

RESULTS of three sets of investigations looking to the improvement of internal-combustion-engine performance are set forth herein. The first set was with multiple ignition, the second with high compression, and the third with the comparative behavior of a variable-compression engine when operating as a constant-clearance engine and when operating with constant compression.

The tests with multiple ignition indicate that it increases the power about 9 to 10 per cent at full throttle and generally gives smoother operation than ignition with a single spark-plug, especially on the leaner air-fuel mixtures.

Increasing the compression ratio from 5.3 to 1 to 10 to 1 resulted in a 13-per cent increase in the power developed by the engine.

Operating the engine on the constant-compression principle resulted in a fuel saving of as much as 34 per cent. The thermal efficiency was increased in the same amount, and the exhaust temperatures dropped more rapidly at reduced loads under constant compression than in the conventional constant-clearance operation.

Fixed spark is entirely feasible under constant-compression operation. Combustion is much better than it is with constant-clearance operation and this should result in less carbon deposition and less crankcase-oil dilution.

THE purpose of this paper is to show the results of certain investigations looking to the improvement of engine performance. Three sets of experiments have been made. The first was an investigation of multiple ignition made at Ohio State University about 2 years ago. The second and third investigations have been made at Purdue University, using a variable-compression engine. The second set embraced some experiments at high compression that has been made possible by the development of an interesting engine-fuel by Dr. C. B. Forward, of Urbana, Ohio. The third investigation concerns the comparison of the behavior of an engine when operating as a constant-clearance

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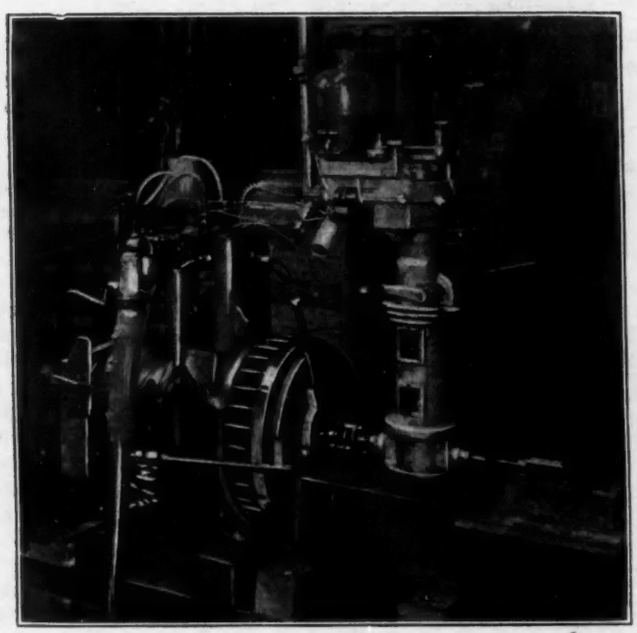


FIG. 1—SET-UP FOR TESTING MULTIPLE IGNITION

This Consists of a 2½ x 5-In. Delco Engine and an Auxiliary Generator That Was Required To Absorb the Engine Power When a Larger Carbureter Was Fitted. A Special Head, Shown in Fig. 2, Was Fitted to the Engine, Which Was Operated at 1060 R.P.M. at Full Throttle-Opening for All Tests. The Number of Sparking Points, the Spark-Advance, and the Mixture Strength Were Varied

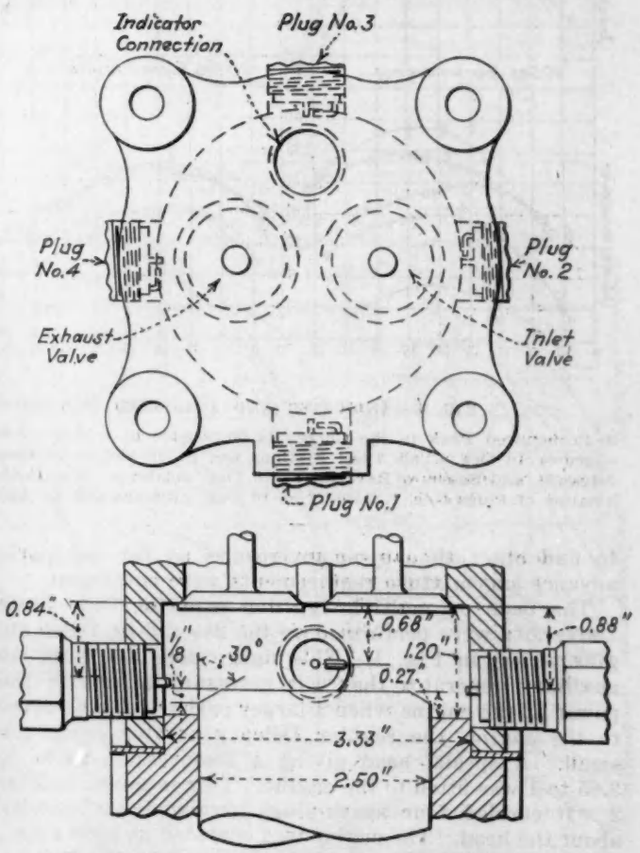


FIG. 2—SPECIAL HEAD HAVING FOUR SPARK-PLUGS

The Spark-Plugs Are Inserted Horizontally at Opposite Points on the Four Sides and Are Designated as Nos. 1, 2, 3 and 4, No. 3 Being Adjacent to the Inlet Valve and No. 4 Adjacent to the Exhaust Valve. This Head Gives a Compression Ratio of 3.65 to 1

engine with its behavior when operating with constant compression.

Multiple ignition, while adding slightly to the cost of an engine, gives certain benefits; notably, an increase of about 9 to 10 per cent in the power at full throttle and generally smoother operation, especially on the leaner mixtures. Increasing the compression ratio of an engine from 5.3 to 1 to 10 to 1 resulted in an increase in power of at least 13 per cent. Operating an engine on the constant-compression principle resulted in a fuel saving of as much as 34 per cent, which means that the mileage of a vehicle at ordinary driving speeds would be increased by about 50 per cent.

Multiple Ignition Increases Power and Economy

Certain work had been done with multiple ignition, notably at McCook Field, but no attempts had been made to find other than optimum results so far as spark-advance and mixture requirements were concerned.

The tests on multiple ignition made at Ohio State University were performed on the 2½ x 5-in. Delco engine shown in Fig. 1. This figure does not show an auxiliary generator that was necessary to absorb the power of the engine when a larger carbureter was fitted to the engine, the regular Delco generator being too small. A special head giving a compression ratio of 3.65 to 1 was fitted to the engine. This is shown in Fig. 2. It carried four spark-plugs arranged horizontally about the head. The engine was operated at 1060 r.p.m. with full throttle for all tests, the number of sparking points, the spark-advance, and the mixture strength being changed. The fluid reactions in each of the investigations described were observed with the use of one of my high-speed engine-indicators. The results are presented in graphical form in Figs. 3, 4, 5 and 6.

It will be noted in Fig. 3 that the curves for indicated and delivered horsepower show a pronounced peak at a spark-advance of 10 deg. These curves flatten out at 20 and 30 deg. spark-advance and show a reversal when 40 deg. advance was used. The combination of spark-plugs Nos. 1, 2 and 3 at 10 deg. advance and an air-fuel ratio of 14.5 to 1 gave 3 per cent more power than any other combination and 9½ per cent more than ignition with a single spark-plug at its best setting, which would be about 25 deg. (See Fig. 5, air-fuel ratios of 13 and 14.)

Since this combination of three plugs is not easily made in an ordinary automotive engine, only the combination of plugs Nos. 1 and 3, which is easily feasible, will be considered in comparison with the single spark-plug. This combination shows about 4½ per cent more power than the single plug at an air-fuel ratio of 14 to 1 in this very small cylinder, or it would give the same power on an air-fuel ratio of 17.5 to 1, presenting a saving of 23 per cent in fuel consumption, as can be deduced easily from Figs. 4 and 5. The combination of plugs Nos. 1 and 3 gives better power and lower fuel-consumption with 10 deg. advance than the single plug at any spark-advance, thus showing the value of "holding your fire". With the more or less general adoption of high compression, it usually is necessary to operate with less spark-advance. The two plugs make this possible with a very slight resultant reduction in power.

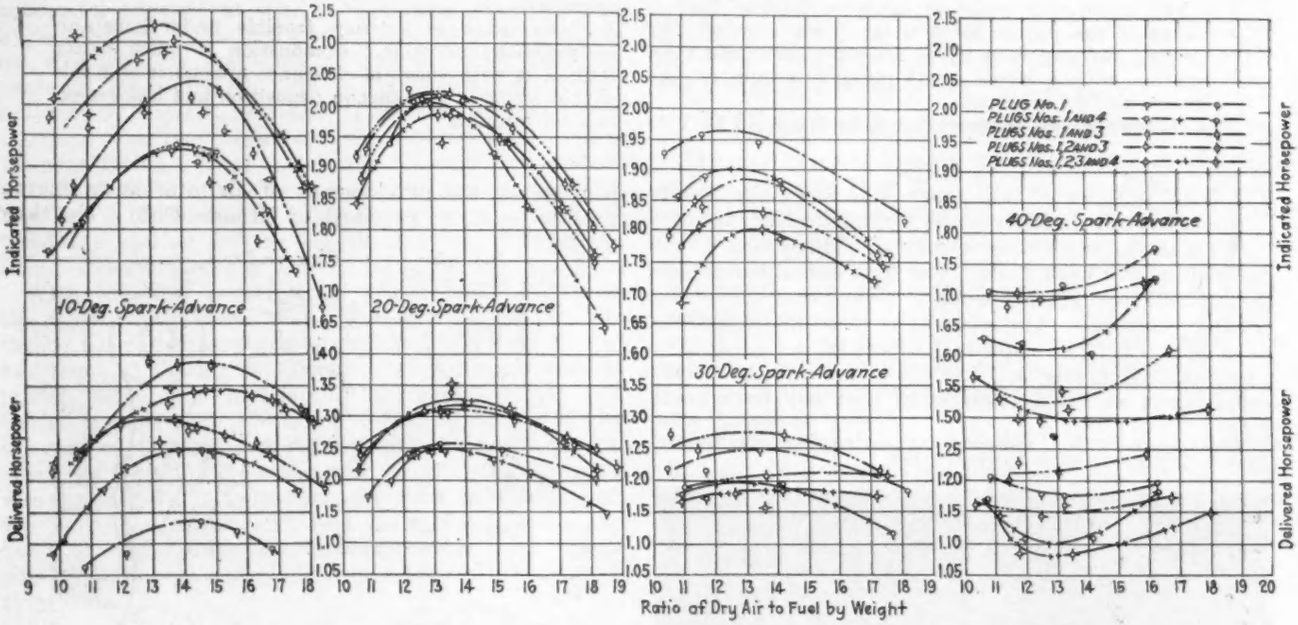


FIG. 3—INDICATED AND DELIVERED HORSEPOWER WITH DIFFERENT SPARK-PLUG COMBINATIONS

A Pronounced Peak in the Curves Is Noticeable at a Spark-Advance of 10 Deg. This Peak Flattens Out at 20 and at 30-Deg. Advance, and Shows a Reversal at 40 Deg. Advance. The Combination of Plugs Nos. 1, 2 and 3 at 10 Deg. Advance and an Air-Fuel Ratio of 14.5 to 1 Gave 3 Per Cent More Power than Any Other Sparking Combination, and Gave 9½ Per Cent More Power than Ignition with a Single Spark-Plug at the Best Setting of about 25 Deg. Advance

Smoother Operation with Two-Plug Ignition

A real value of this combination of two-plug ignition is that of having more reliable and certain ignition, as is evident from the indicator cards shown in Fig. 7, in which the raggedness during the early part of the expansion stroke, noticeable in the other cards, disappears when this combination is used. This raggedness with the single plug probably is caused by variations in the mixture at the spark-plug from cycle to cycle when ignition occurs. Ignition from two opposite plugs smooths

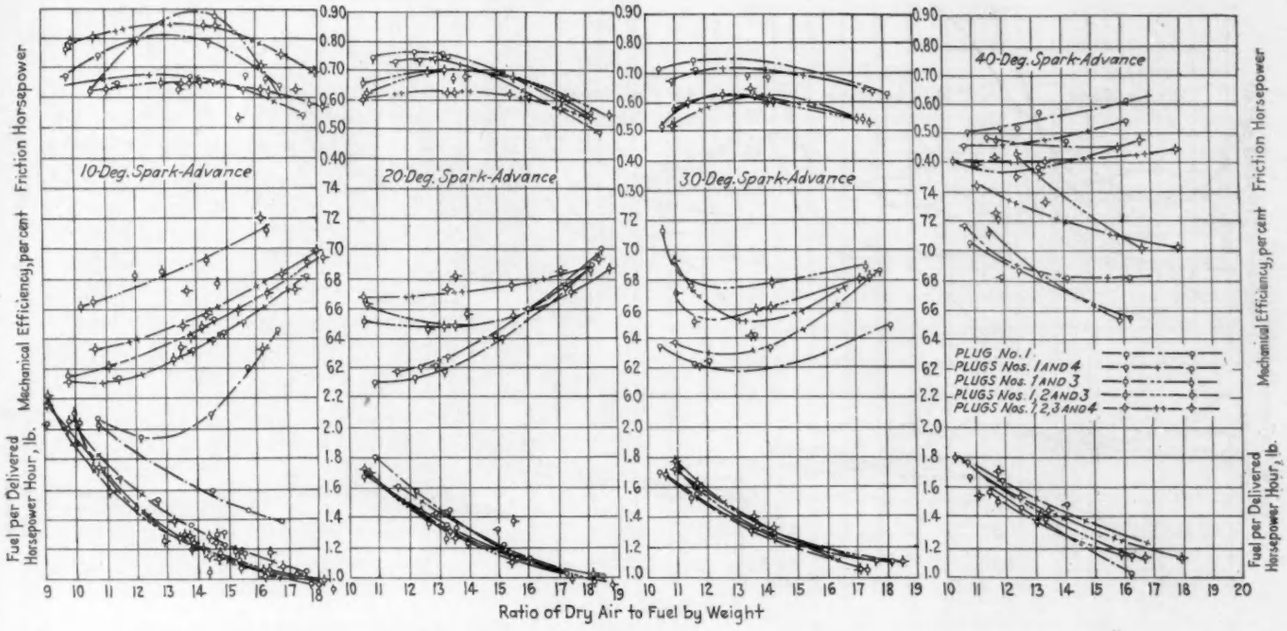

10-Deg. Spark-Advance
20-Deg. Spark-Advance
30-Deg. Spark-Advance
40-Deg. Spark-Advance
PLUG No. 1
PLUGS Nos. 1 AND 4
PLUGS Nos. 1 AND 3
PLUGS Nos. 1, 2 AND 3
PLUGS Nos. 1, 2, 3 AND 4
Friction Horsepower
Mechanical Efficiency, per cent
Fuel per Delivered Horsepower Hour, lb.
Ratio of Dry Air to Fuel by Weight

FIG. 4—FRICTION HORSEPOWER, MECHANICAL EFFICIENCY AND FUEL CONSUMPTION AT DIFFERENT SPARK-ADVANCES

Dual Ignition with the Combination of Spark-Plugs Nos. 1 and 3, Which Is Easily Feasible in the Conventional Automobile Engine, Shows about 4½ Per Cent More Power than When a Single Plug Is Used at an Air-Fuel Ratio of 14 to 1, or Would Give the Same Power on an Air-Fuel Ratio of 17.5 to 1, Presenting a 23-Per Cent Saving in Fuel Consumption, as Can Be Deduced from the Curves Reproduced Herein and from Those for Different Air-Fuel Ratios, Which Are Shown in Fig. 5

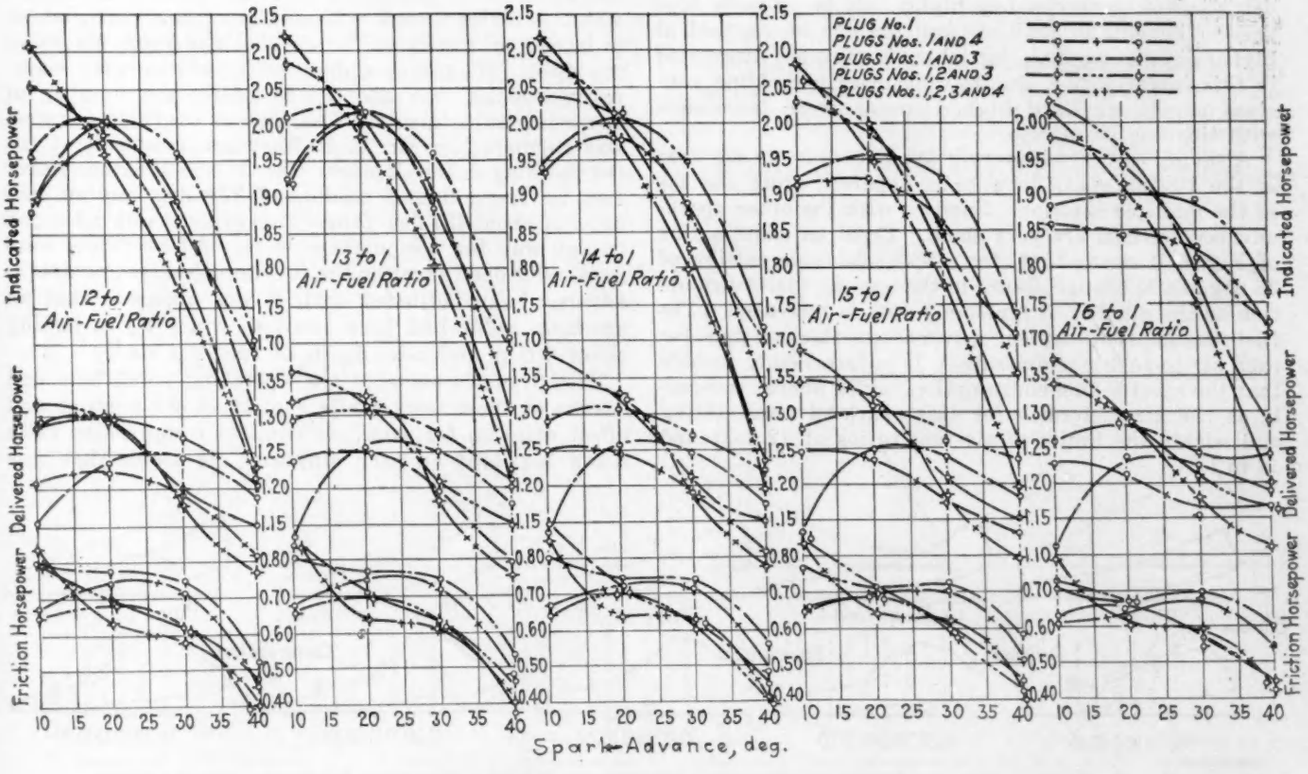

12 to 1 Air-Fuel Ratio
13 to 1 Air-Fuel Ratio
14 to 1 Air-Fuel Ratio
15 to 1 Air-Fuel Ratio
16 to 1 Air-Fuel Ratio
PLUG No. 1
PLUGS Nos. 1 AND 4
PLUGS Nos. 1 AND 3
PLUGS Nos. 1, 2 AND 3
PLUGS Nos. 1, 2, 3 AND 4
Indicated Horsepower
Delivered Horsepower
Friction Horsepower
Spark-Advance, deg.

FIG. 5—INDICATED, DELIVERED AND FRICTION HORSEPOWER AT DIFFERENT AIR-FUEL RATIOS

Better Power and Lower Fuel-Consumption Result with a 10-Deg. Spark-Advance When Using the Combination of Nos. 1 and 3 Spark-Plugs than with Any Other Combination at Any Spark-Advance. General Adoption of High Compression Makes It Usually Necessary To Operate with a Very Small Spark-Advance. Use of the Two Plugs Makes It Possible To Operate with a Small Spark-Advance with Only a Very Slight Resultant Reduction in the Power Developed

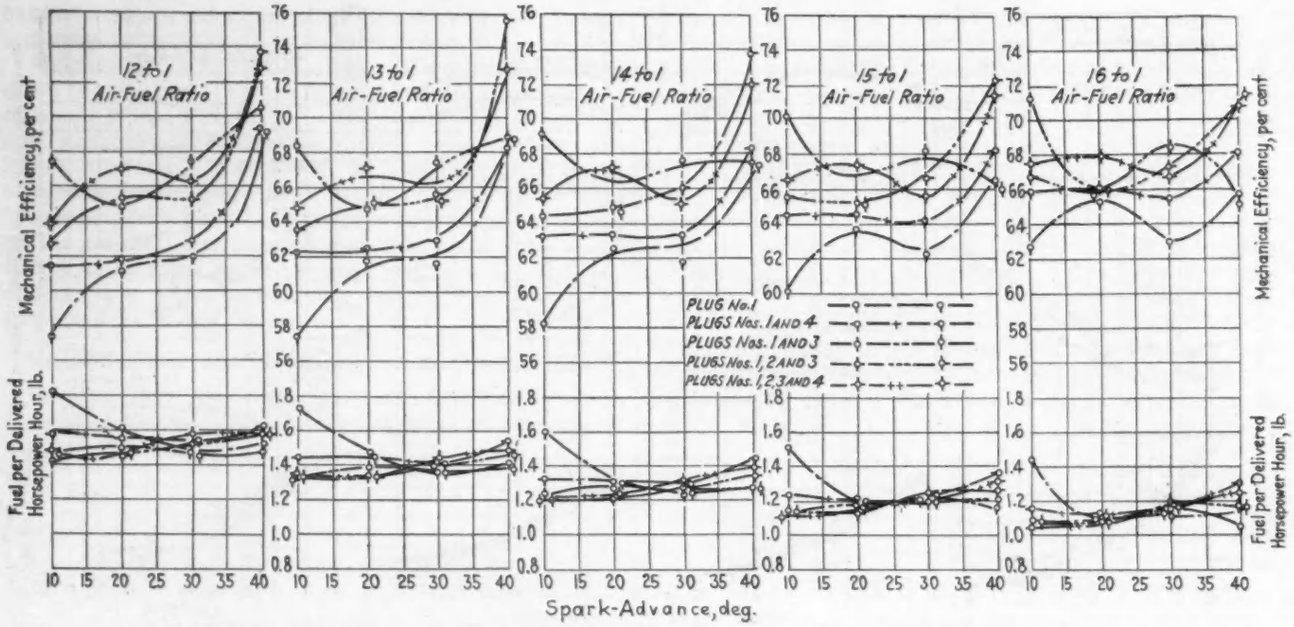

12 to 1 Air-Fuel Ratio
13 to 1 Air-Fuel Ratio
14 to 1 Air-Fuel Ratio
15 to 1 Air-Fuel Ratio
16 to 1 Air-Fuel Ratio
Mechanical Efficiency, per cent
Fuel per Delivered Horsepower Hour, lb.
PLUG No.1
PLUGS Nos. 1 AND 4
PLUGS Nos. 1 AND 3
PLUGS Nos. 1, 2 AND 3
PLUGS Nos. 1, 2, 3 AND 4
Spark-Advance, deg.

FIG. 6—MECHANICAL EFFICIENCY AND FUEL CONSUMPTION AT DIFFERENT AIR-FUEL RATIOS

out the diagram, indicating more uniform fluid reactions. The impression in the tests was always that the engine ran smoother with this combination than with spark-plugs Nos. 1 and 4 or with plug No. 1 alone firing. This benefit probably would be more evident at partial-throttle loads when the mixture within the cylinder was not compressed so highly. It is probable that greater benefits of multiple ignition can be realized at higher engine-speeds. Partial loads were not attempted in this investigation, due to difficulties in holding constant conditions; and higher speeds were impossible with this engine set-up.

A saving of fuel amounting to as much as 28 per cent at the 10-deg. spark-advance is apparent from the use of the multiple ignition. Savings with the other spark-advance settings are very small. From an examination of Fig. 6 it seems that, for a spark-advance setting of 25 deg., little change occurs in the specific fuel-consumption as the number of ignition points is increased. The fuel-consumption curves converge at this setting for each air-to-fuel mixture-ratio. It is interesting to note that the specific fuel-consumption varies almost inversely as the air-fuel ratio for this spark-advance setting and within the limits of air-fuel ratios of 12 to 1 and 16 to 1.

GAINS MADE WITH HIGH COMPRESSION

The variable-compression engine used in the last two investigations is shown in Fig. 8. It is a 3 x 4-in. overhead-valve type fitted with a movable head so that the clearance volume can be changed easily by means of the micrometer screw shown at the top. The engine, which is water cooled, with thermosiphonic circulation, is loaded by means of the cradled generator shown at the right. The thermosiphon cooling system with evaporative cooling was adopted to lessen the number of operating adjustments. The fuel, as previously stated, was furnished by Dr. C. B. Forward, president of the Oil Refining & Development Co. It was a rather heavy fuel, having a Baumé reading of 32.8 deg. and an end-point of about 437 deg. fahr. This product was not doped in any way for use in these tests. All test runs were made with open throttle, the fuel needle-valve and spark-advance being adjusted until it was apparent that an optimum point had been reached, when a run lasting about 6 min. and using ¼ lb. of fuel was made.

Fig. 9 shows some of the operating conditions and results of these tests, while Fig. 10 shows a power and offset diagram for each test run, the compression ratio being indicated on each diagram. It seems that this

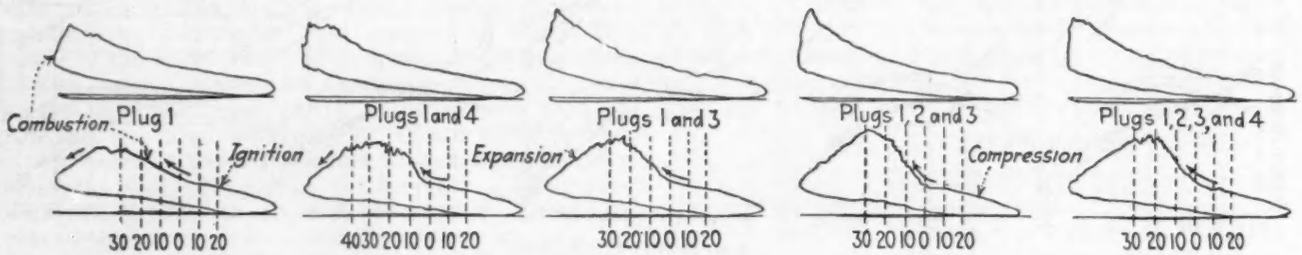


FIG. 7—TYPICAL ENGINE DIAGRAMS SHOWING EFFECTS OF VARIOUS MULTIPLE-IGNITION COMBINATIONS

More Reliable and Certain Ignition Is Obtained with the Combination of Spark-Plugs Nos. 1 and 3 than with the Single Plug or with Plugs Nos. 1 and 4, as Is Evident by the Smoothness of the Diagram During the Early Part of the Piston Stroke. Raggedness with the Single Plug Probably Is Caused by Variations in the Mixture at the Spark Points from Cycle to Cycle When Ignition Occurs. Ignition from Two Opposite Spark-Plugs Smooths Out the Diagram, Indicating More Uniform Fluid Reactions. It Is Probable that Greater Benefits of Multiple Ignition Can Be Realized at Higher Engine-Speeds

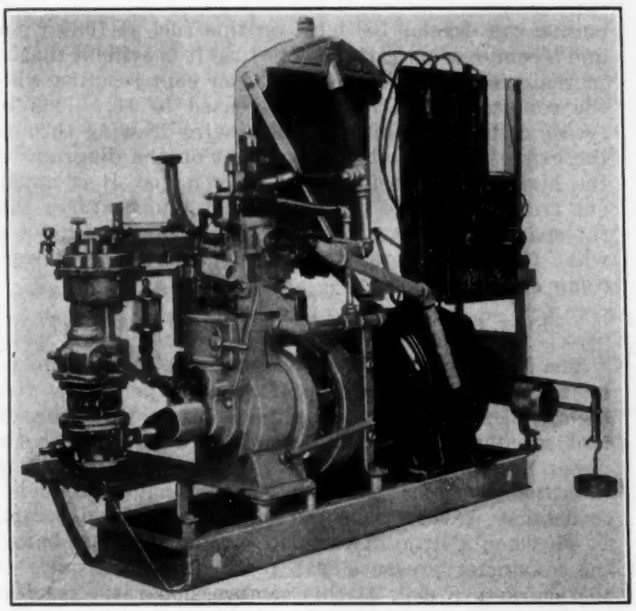


FIG. 8—VARIABLE-COMPRESSION ENGINE USED FOR HIGH-COMPRESSION CONSTANT-CLEARANCE AND CONSTANT-COMPRESSION TESTS

This Is a 3 x 4-In. Overhead-Valve Type Fitted with a Movable Head so that the Clearance Volume Can Be Changed Easily by Means of the Micrometer Screw at the Top. It Is Water-Cooled, with Thermosiphonic Circulation. The Engine Is Loaded by Means of the Cradled Generator at the Right. A Special Fuel, Having a Baumé Reading of 32.8 Deg. and an End-Point of about 437 Deg. Fahr., but Not Doped in Any Way, Was Used. All Test Runs Were Made with Wide-Open Throttle, the Needle-Valve and Spark-Advance Being Adjusted to the Optimum Point, When a Run Was Made Using ¼ Lb. of Fuel and Lasting about 6 Min.

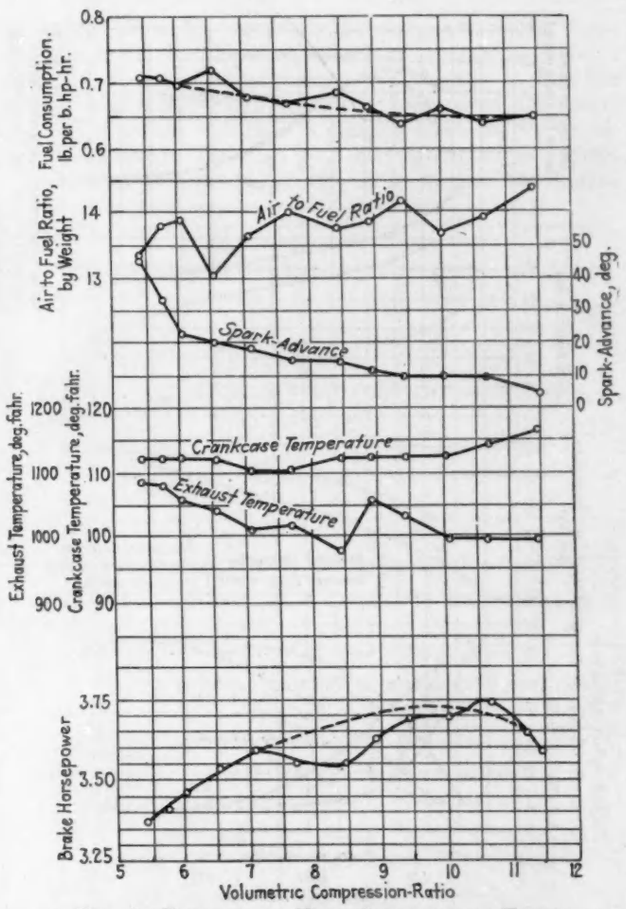


FIG. 9—RESULTS OF HIGH-COMPRESSION TESTS

These Curves Show Decrease in Fuel Consumption and in Exhaust-Gas Temperature and Increase in Brake Horsepower as the Volumetric Compression Is Increased, the Air-Fuel Ratio Increased and the Spark-Advance Retarded. The Engine Was Run at 1080 R.P.M. and a 210 to 212-Deg. Fahr. Cooling-Water Temperature

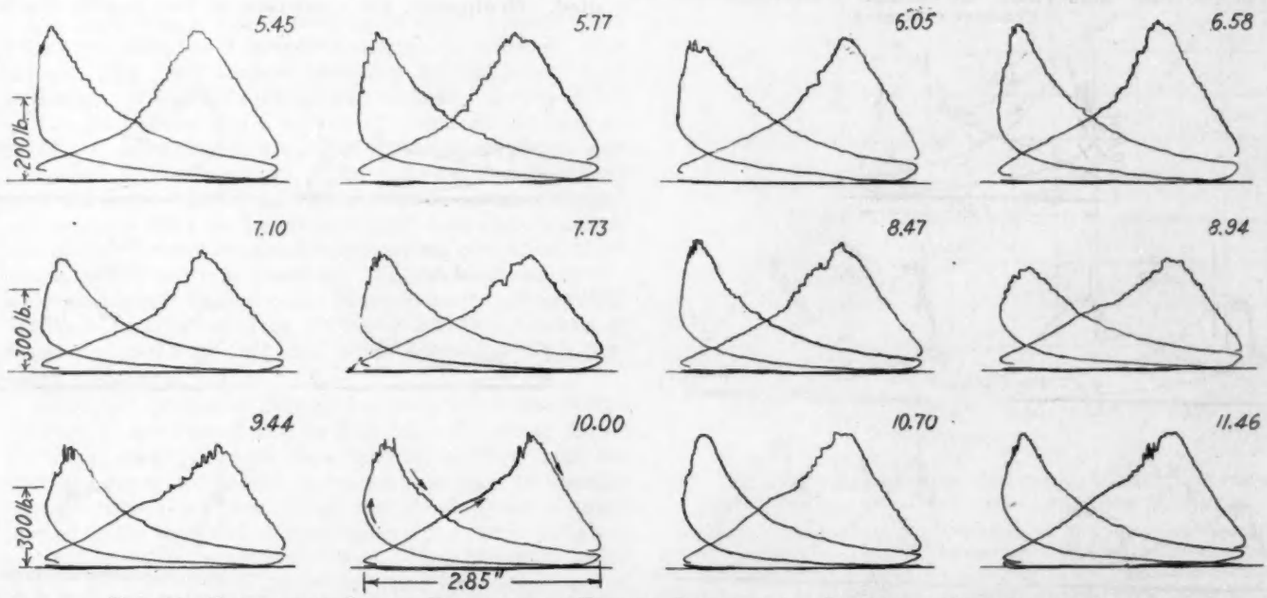


FIG. 10—POWER AND OFFSET DIAGRAMS OF ENGINE OPERATION AT DIFFERENT COMPRESSION RATIOS

The Compression Ratio for Each Test Run Is Shown on the Diagram for the Run. An Increase of Power of about 13.3 Per Cent Resulted When the Compression Ratio Was Increased from 5 to 10, Despite a Little Wire-Drawing through the Exhaust Ports, Which Is Evident on the Diagrams at the Higher Compression-Ratios. The Diagrams Show that the Fuel Manifested No Tendency To Detonate at Any Compression Ratio Lower than 11.46

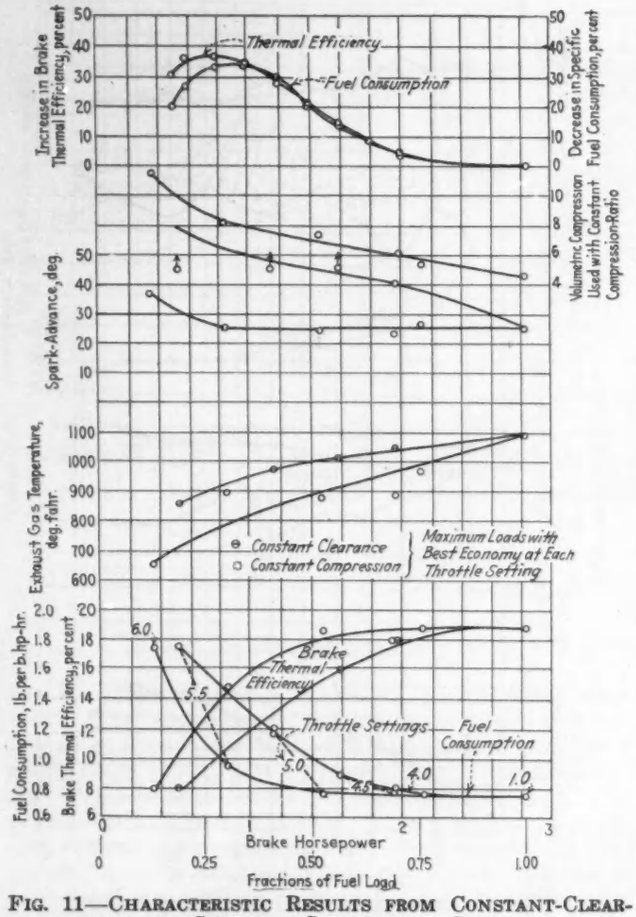


FIG. 11—CHARACTERISTIC RESULTS FROM CONSTANT-CLEARANCE AND CONSTANT-COMPRESSION OPERATION

The Engine Developed More Power at the Respective Throttle-Settings When Operating on Constant Compression than When Operating at Constant Clearance. At a Setting of 5 It Developed 28.5 Per Cent More Power, and at a Setting of 5.5 It Developed 60 Per Cent More Power, on Constant Compression than on Constant Clearance

engine can develop 3.3 b.hp. on this fuel at 1080 r.p.m. and a compression ratio of 5 to 1, so it is evident that an increase in power of about 13.3 per cent resulted when the compression ratio was increased to 10. This increase resulted in spite of a little wire-drawing through the exhaust ports, which is evident on the diagrams at the higher compression-ratios. Then, too, it is apparent from the record of the exhaust temperatures that the spark might have been advanced or retarded somewhat for some of the test runs, particularly between compression ratios of 7½ and 10.

FUEL CONSUMPTION DECREASED 10 PER CENT

The fuel consumption dropped from 0.71 lb. per b.hp.-hr. to about 0.64 lb., a drop of about 10 per cent. Had the cylinder temperatures been held lower, it is probable that greater gains would have been made in both the power and the lowered specific fuel-consumption. The indicator diagrams show that the fuel had no tendency to detonate except when the compression ratio became 11.46, when a little disturbance was shown just before the maximum pressure was reached. An advance of the spark to 8 deg. at this compression ratio resulted in a not disagreeable knock. A further advance to 15 deg. brought about a severe knock with a slight lowering of engine-speed, while a 30-deg. advance gave a very severe knock with a great decrease in engine-speed.

The engine operated very smoothly for all test runs on this fuel and was then available, without changes or overhauling, for the work done at constant clearance and constant compression. This engine never has developed more than 3.13 b.hp. on commercially available fuels, at compression ratios up to or slightly above 5 to 1 at 1080 r.p.m., so these high compressions resulted in a gain of 19.5 per cent in power with this fuel, which, to say the least, is a gain worth trying for in future development.

An interesting feature of operation at high compression is that the exhaust temperatures decrease rapidly. This seems entirely logical, since combustion is accelerated. Ordinarily, the crankcase of this engine reaches

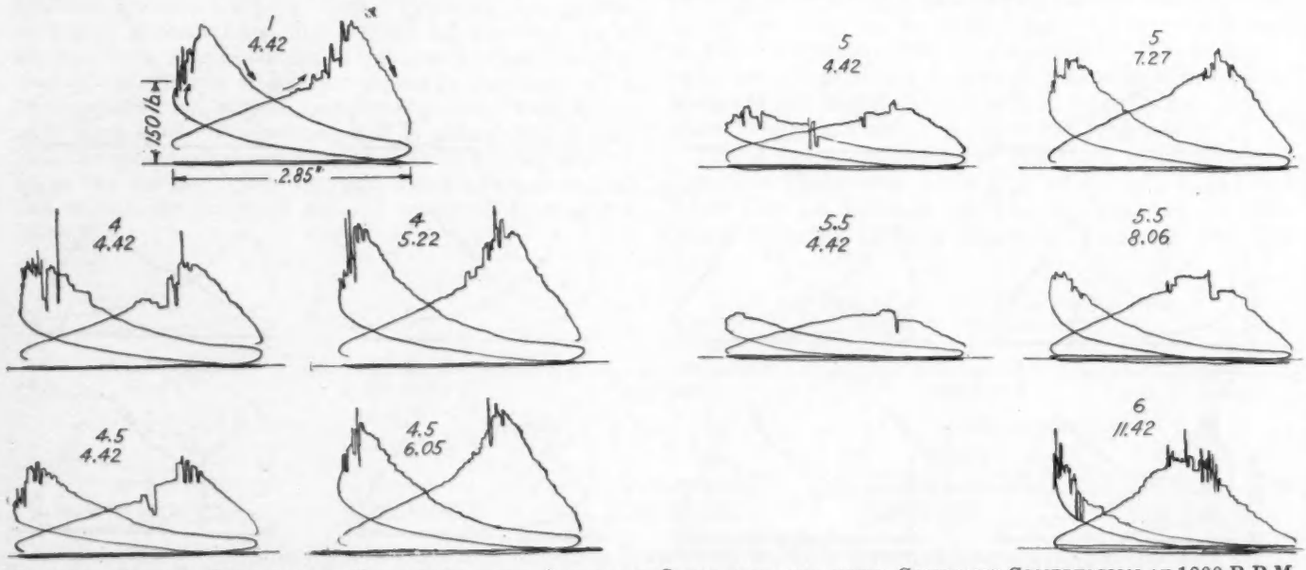


FIG. 12—TYPICAL DIAGRAMS OF OPERATION WITH CONSTANT CLEARANCE AND WITH CONSTANT COMPRESSION AT 1000 R.P.M.

It Is Clear from These that Combustion Is Much Better with Constant Compression (the Right Diagram of Each Pair) than with Constant Clearance (the Left Diagram). This Probably Would Result in Less Carbon Deposition and Less Crankcase-Oil Dilution. All the Diagrams for Constant Compression Show the Tendency To Detonate, While Those at Light Loads at Constant Clearance Show a Tendency To Miss Occasionally. The Upper Number on Each Diagram Indicates the Throttle Setting and the Lower, the Compression Ratio. With a Throttle Setting of 6 the Engine Would Not Run with a Constant Clearance

a temperature of 120 deg. fahr. after 2 hr. of operation at a compression ratio of about 4 to 1 on ordinary fuel. In this case, the crankcase reached a temperature of only 116 deg. fahr. after about 7 hr. of operation. It seems that there are no serious temperature conditions to contend with when operating at high compressions.

Constant Clearance versus Constant Compression

The experiments reported a few years ago by H. R. Ricardo on an isolated-charge engine had excited the imagination, so it was natural to see what might be done with this variable-compression engine, shown in Fig. 8, wherein the volumetric-compression ratio might be changed for almost any condition. M. J. Zucrow[2] assisted greatly in making these tests.

The engine was first operated at full throttle and 1000 r.p.m. on an easily available fuel so that the full-load compression might be determined. A compression ratio of 4.42, giving a compression pressure of about 75 lb. gage, was decided upon, although it was high enough to cause some detonation at three-quarters and at full load. The engine was then motored with the throttle set at certain arbitrarily chosen points so that the cylinder-head might be adjusted to bring the compression pressure up to the point used for the full-load runs. Series of runs were then made at each throttle setting, with changes made in the needle-valve and spark-advance adjustment so that the most economical setting might be obtained for maximum load at each of these settings. Such series were made both with constant clearance and with constant compression, so that the most economical point might be located for each curve, as in Fig. 11, except for throttle setting 6 under constant compression, where but one run was made. It is probable that this point is slightly high so far as fuel consumption is concerned. The engine could not be made to operate with setting 6 under constant clearance.

Superiority of Constant Compression Shown

The reduction in fuel consumption at the lighter loads when operating on constant compression becomes very evident, the two fuel-consumption curves separating materially at loads under 0.8 of full load. At 0.3 to 0.4 of full load there was a saving of about 34 per cent in specific fuel-consumption. The thermal efficiency was increased a like amount. The exhaust temperatures dropped more rapidly at reduced loads under constant compression than in the conventional constant-clearance operation. Under constant-compression operation, fixed spark seems entirely feasible. No readings of spark-advance beyond 45 deg. could be made easily, so no really accurate figures could be obtained for this feature at loads under 0.7 of full load when operating with constant clearance.

Indicator diagrams obtained during the runs plotted in Fig. 11 are reproduced in Fig. 12. The upper figure in each case indicates the throttle setting and the lower, compression ratio, so it should be easy to identify them. It is clear from these that combustion is much better with constant compression than with constant clearance, as is theoretically true. This probably would result in less carbon deposition and less crankcase-oil dilution. Also, the engine starts easier on partial throttle-opening. All the diagrams for constant-compression operation show the tendency to detonate, while those at light loads for constant-clearance operation show a tendency to miss occasionally. No change in throttle setting was made when changing from constant clearance to constant volume. Changes were made, as already stated, in the fuel and the spark adjustments.

Referring to Fig. 11, it will be seen that the engine

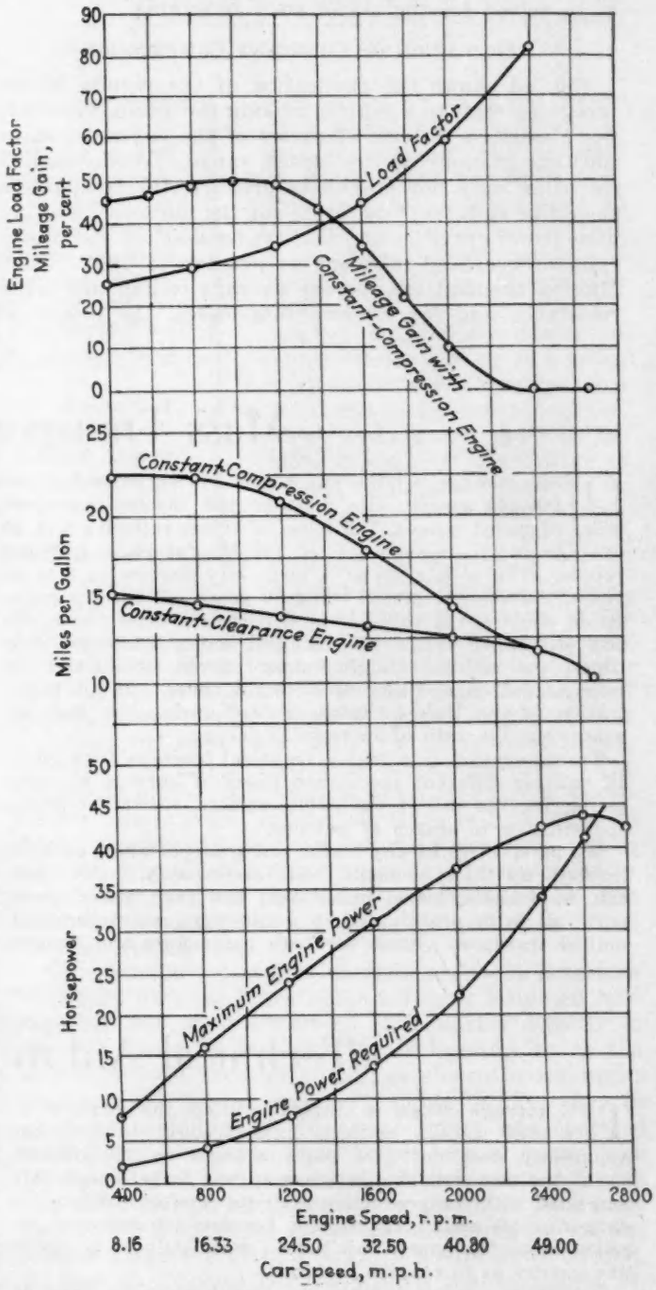


FIG. 13—COMPARATIVE CAR MILEAGE, USING CONSTANT-COMPRESSION AND CONSTANT-CLEARANCE ENGINES

The Curves Represent the Application to a Vehicle of Data Acquired in the Tests, and Indicate that Gains up to 50 Per Cent in Miles per Gallon Might Be Expected from Operation on Constant Compression Instead of on Constant Clearance. This Would Mean a Saving of 33 Per Cent in Fuel Bills. The Engine Power-Curve Is That of a Six-Cylinder Overhead-Valve Engine Used in a Phaeton of 1923 Model, and the Power-Required Curve Was Plotted from Assumptions for Average Rolling and Wind Resistance and for Transmission Losses

[2] M.S.A.E.—Research assistant, Purdue University, West Lafayette, Ind.

developed more power at the respective throttle-settings when operating on constant compression. With the throttle setting of 5, the engine developed 1.49 b.hp. on constant compression and but 1.16 b.hp. on constant clearance, an increase for the former of 28.5 per cent. With the throttle set at 5.5, the increase was from 0.515 to 0.826 b.hp., a gain of 60 per cent. It seems probable that new problems in carburetion would need to be solved for the use of such an engine.

Application of Constant Compression

Fig. 13 shows the application of the results of the foregoing tests to a vehicle, making the assumption that the maximum thermal efficiency of the engine remains constant throughout the speed range. While such a condition does not prevail in practice, the comparison should be sufficiently accurate for the purpose. The engine power-curve is one that was published for a six-cylinder overhead-valve-engine phaeton of 1923 model. Making assumptions for the average rolling and wind resistance and for transmission losses, the power-required curve was plotted, showing a maximum car-speed of 54.5 m.p.h. Since these cars of the model mentioned had a top speed of 53 to 55 m.p.h., this curve is considered entirely reasonable. Comparing the required power with the power available gave the curve of load factors at the top of the group. Then, assuming that the gasoline weighed 6.1 lb. per gal., the miles per gallon were easily computed from the load-factor and the fuel-consumption figures of Fig. 11.

With a constant-compression engine in this car, gains of up to 50 per cent in miles per gallon might be expected over the same car using the conventional engine. This would mean a saving of 33 per cent in fuel bills. With 20,000,000 cars in service, each traveling 6000 miles per year, averaging on constant clearance 15 miles per gal. on gasoline costing 20 cents per gal., the American car owners would save $400,000,000 annually if they used engines operating on constant compression, that gave 33 per cent more mileage at customary driving speeds. The possibility of conserving our national resources is stupendous.

Mass-Transportation in Cities

ON the average, a large city covers 100 sq. miles for each 1,000,000 people. Its metropolitan district has 1000 miles of paved streets, 500 miles of street railways and an average motor registration of 100,000 for each 1,000,000 people. The population of a large city doubles in 5 to 40 years, the average period being 30 years. While the population doubles, the value of land increases three times, the city passenger traffic by rail and motor increases four times, the railroad freight-tonnage seven times, and the railroad passenger-traffic about eight times. Motor registration in the United States doubled during the last 4½ years, but the rate of increase is falling.

Transportation is a highly technical business with 10 or 12 entirely different specialized types of carrier, all competing for the use of the public streets, either for actual operation or in search of patrons.

My perspective of any traffic and transportation problem involves all these elements: rail, motorcoach, truck, taxicab, automobile, horse, pedestrian, and even water transport; all to be coordinated in a city-wide, well-integrated, unified transport system for both passengers and freight, with "track and service" capacity adjusted to local needs, and with recognition of the differentials in speed and bulk of these various transport agencies.

It needs no demonstration that the widespread use of private motor-vehicles in rush-hour transportation is due largely to the demand for speed, increasing with the spread of our cities which are distinctly trending toward reducing the average density of population, as the American standard of home life rises.

A modern transit system handles 20 per cent of the total traffic in the maximum rush hour, and at least the entire population once every day.

After years of study of transit and traffic and the practical aspects of city planning, zoning and motor transport, I submit the proposition that the electric car, mainly surface transit, is still the essential backbone of passenger mass-transportation, which neither the motorcoach, taxicab, jitney, or private motor-car can displace, at least until our cities can finance adequate replanning. The volume of movement is too great for small units.—J. Rowland Bibbins in *Engineers and Engineering*.

Technical Aid in National Problems

THE average citizen is pleased to enjoy the comforts of life that modern methods have brought to him, but apparently does not give much thought to the difficult social and economic changes that appear to be inseparably connected with the production of these comforts. When the danger to his social organization becomes too apparent, he makes haste to "pass a law" often with little or no scientific inquiry as to reasons or results.

One of our greatest problems, therefore, is to bring to the aid of governmental bodies the technical advice and knowledge of our professional groups. This will be no easy matter, for obviously legislative bodies must be free to work out their own solutions. But, nevertheless, it would appear to be logical that if all of the professional groups had some means of expressing themselves nationally they could be of great service. The American Bar Association is such a body and one that has done much to advance sane legislation. The American Engineering Council also has already amply justified its existence.

It should be remembered that the professional groups all together constitute only a small part of our population. The entire body of technically trained scientists and engineers are but a small handful, relatively speaking. Yet this small handful has revolutionized industry and is now reforming our National habits and our economic and social needs. The methods by which all this has been accomplished are also applicable to the solution of some of these economic and social problems. It remains to be seen how these principles can be utilized to these ends. For if government of the people, by the people and for the people shall fail us, it will not be because of lack of able representatives or of loyalty of the people at large, but because we shall not be able to bring to bear upon these difficult National problems the same kind and degree of technical skill and knowledge that has been responsible for bringing them into existence.—From presidential address by Dean D. S. Kimball at annual meeting of the American Engineering Council.

Airport Lighting

By H. E. MAHAN[1]

AERONAUTIC MEETING PAPER — *Illustrated with* CHARTS AND PHOTOGRAPHS

The essential items and general practice in the lighting of airports for night operation are briefly outlined. No attempt has been made to discuss in detail the many problems involved in developing and improving lighting facilities, nor are the subjects of airways, signaling and the lighting equipment of airplanes considered.

Much research and investigation are being devoted to the general subject, but this paper includes only an outline of the present practice in the lighting of the airport proper.

THE success of commercial aviation demands that operation continue throughout the hours of darkness and that the artificial light provided during this period shall add no hazards that will interfere with the safe and practical conduct of the airport activities. The problem has been approached from the point of view of the engineer, the aviator being relied upon to contribute his experience in establishing the requirements and judging the effectiveness of the facilities provided. It is quite in order to pay tribute to the efficient service rendered by the aeronautics bureaus of the Army, the Navy and the Department of Commerce in functioning as a clearing-house for data and in establishing the working standards that have been found best by practice. The practice in the lighting of airports follows definite principles, which is highly desirable, for all airports will therefore have a familiar appearance from the air at night and a pilot who lands at a strange port will not be confused by novel or unfamiliar lighting features.

The lighting facilities believed essential for the safe and efficient night operation of an airport are (*a*) an airport beacon, (*b*) boundary lights, (*c*) field floodlighting, (*d*) an illuminated wind-direction indicator, (*e*) obstruction and airport lights, and (*f*) a ceiling projector.

BEACONS OF 8,000,000 CP.

The beacon is intended to indicate the location of the airport from distant points. A beam of several million candlepower has been found desirable for this purpose and, so that it may be visible from all directions, the beacon is revolved, so that, from any one point, it gives the effect of a flashing light. A typical form of revolving beacon is illustrated in Fig. 1. This consists of a 24-in. parabolic glass mirror in the focus of which is placed a 900-watt 30-volt, or a 1000-watt 110-volt, T-20 Mazda lamp. The former lamp, having a more concentrated filament than the latter, delivers a higher beam-candlepower, namely approximately 8,000,000 as against 2,300,000, and is, therefore, preferable for this class of service. The electric current available at most airports is alternating, which makes it convenient to operate the low-voltage lamp by a transformer. To increase its range of visibility, the practice is to place the beacon on a steel tower from 50 to 75 ft. high, or on top of a hangar or other building. The beam is elevated approximately one-half its width above the horizontal, which places the lower edge of the beam on the horizontal; that is, a 3-deg. beam would be elevated 1½ deg. above the horizontal.

When beacons are placed at remote locations along an airway, it is customary to equip them with automatic lamp-changers, which place a new lamp in the focus in event of the failure of a lamp. This is not regarded as necessary at terminal ports, where attendants are present to maintain the equipment.

Upon his arrival over the field, the pilot is made aware of the shape and extent of the field by means of boundary lights. These are usually of 600-lumen (60-cp.) size, spaced on 200 to 300-ft. centers, and are operated from a series circuit. This form of distribution is more economical for the lengths of runs necessary for most fields than is multiple distribution, although the latter system is sometimes used. The series circuit is fed from a constant-current transformer, the primary voltage of which is from 2200 to 2400; delivers 6.6 amp. of constant current; and is remotely controlled through an automatic controller by a push-button at any convenient point on the field. The hazard of manually switching a high-potential circuit is thus avoided.

The distribution system consists of No. 8 American wire-gage parkway cable, which is rubber insulated, lead sheathed and steel armored. It is buried directly in the soil about 12 in. deep and is brought up to the boundary light through piping, as shown in the upper drawings of typical boundary lights in Fig. 2. In some cases individual boundary lights are operated from a series-multiple transformer located in the base of the pedestal, the primary of which is connected with the series circuit. This method is shown at the bottom in Fig. 2 and offers the advantage of keeping the voltage that is above the ground down to a safe limit, so that, in case an airplane collides with a boundary-light fitting, the likelihood of fire or injury to life or property is minimized. When the units are operated directly from the series circuit, an automatic cut-out should be provided to maintain the continuity of the circuit in the event of a lamp failure.

The boundary light is supported by a pipe embedded in concrete, or otherwise made rigid, and in general is elevated about 3 ft. above the ground. The unit itself consists of a weather-proof casing, which supports a

[1] Illuminating engineering laboratory, General Electric Co., Schenectady, N. Y.

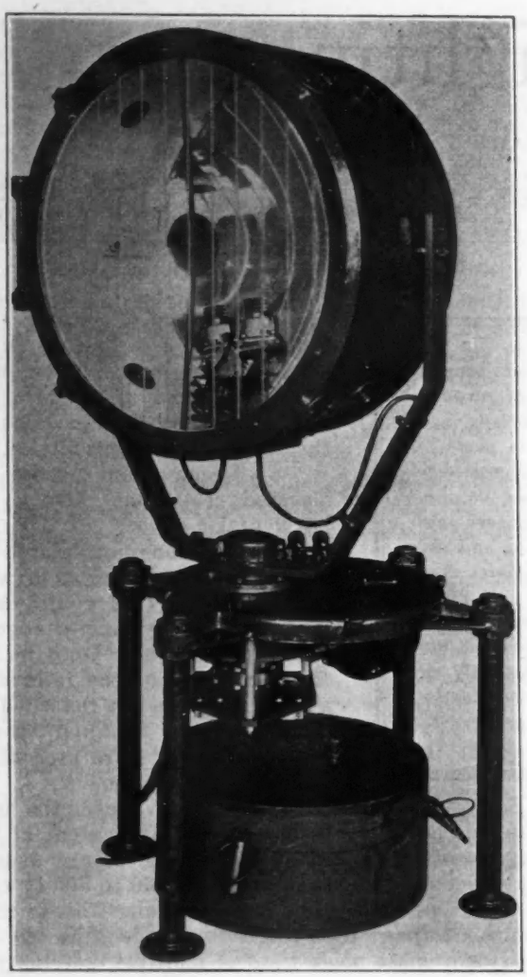


FIG. 1—REVOLVING BEACON OF ABOUT 8,000,000 CP.
This Consists of a 24-In. Parabolic Glass Mirror in the Focus of Which Is Placed a 900-Watt, 30-Volt, T-20 or a 1000-Watt, 100-Volt, T-20 Mazda Lamp

clear or prismatic glass globe in which the lamp is enclosed.

OBSTRUCTION AND APPROACH LIGHTS

Buildings, pole lines, radio towers, and the like, that are within the gliding distance of the field, are regarded as obstructions and are marked with a red light installed at the highest point of the obstruction and visible from all sides. A unit constructed like the boundary light is used for this purpose, except that it is equipped with a red globe and, because of the absorption of light by the red glass, a lamp of at least 1000 lumens (100 cp.) is used. A green globe on this same unit

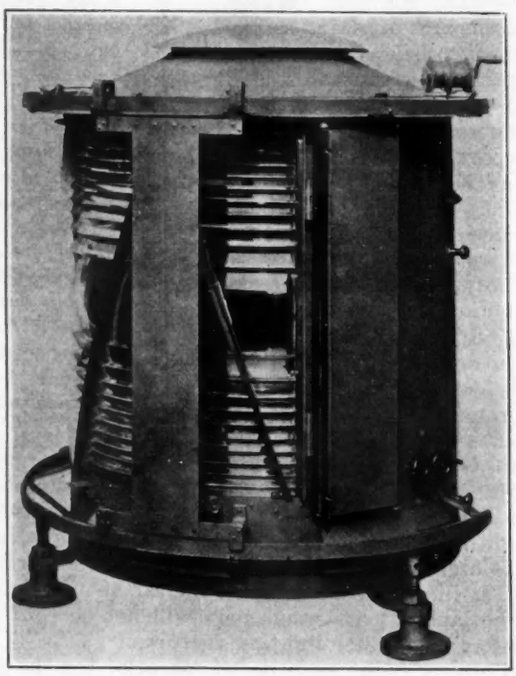


FIG. 3—LARGE AIRPORT FLOODLIGHT USING ELECTRIC ARC
The Unit Comprises a Waterproof Casing That Supports a 3 Ft. 6 In. x 4 Ft. 8 In. Lens and Encloses a 150-Amp. High-Intensity Arc Mechanism. It Delivers a Fan of Light of Approximately 180-Deg. Horizontal Spread

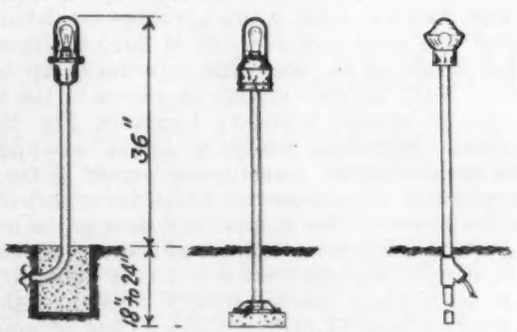
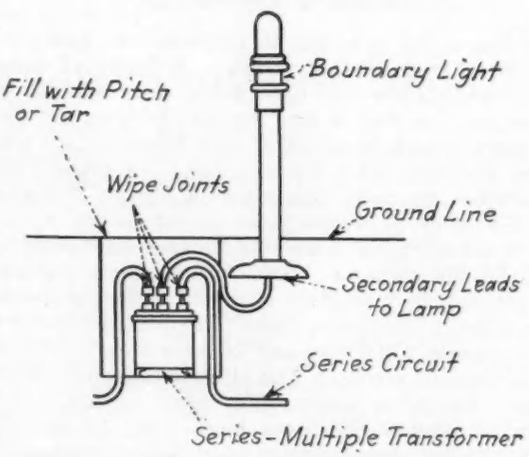


FIG. 2—TYPICAL FORMS OF BOUNDARY LIGHT
No. 1 American Wire-Gage Parkway Cable Is Used in the Distribution System. This Cable is Rubber Insulated, Lead Sheathed and Steel Armored. It Is Buried Directly in the Soil about 12 In. Deep, and Is Brought Up to the Boundary Light through Piping as Shown in the Three Drawings Above. A Boundary Light with an Individual Series-Multiple Transformer Located in the Base of the Pedestal Is Shown in the Right-Hand Drawing. In This the Primary Is Connected with the Series Circuit. This Method



Has the Advantage of Keeping the Voltage That Is above Ground Down to the Safe Limit, so that, in Case an Airplane Should Collide with a Boundary-Light Fitting, the Likelihood of Fire or Injury to Life or Property Will Be Minimized

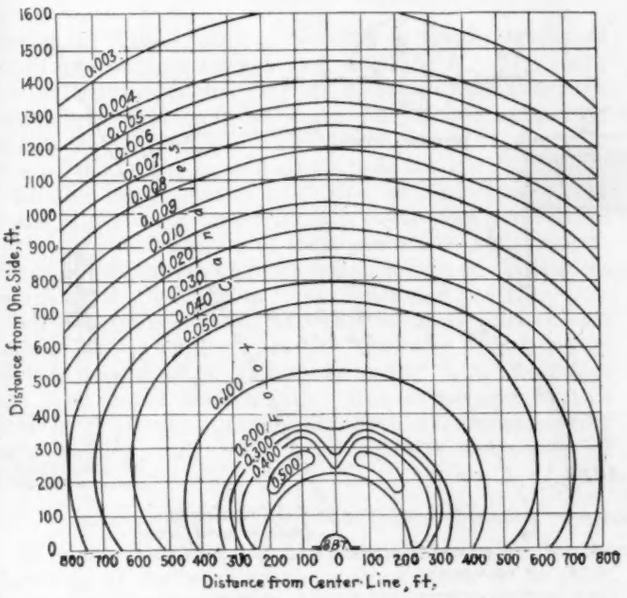


FIG. 4—ISOLUX CURVES OF DISTRIBUTION OF VERTICAL ILLUMINATION FROM LARGE AIRPORT FLOODLIGHT

These Are for the Floodlight Illustrated in Fig. 3 When a 150-Amp. 110-Volt, High-Intensity Arc Is Used. The Curves Indicate the Illumination in Foot-Candles in a Plane at Right Angles to the Field at Varying Distances from the Unit

indicates an approach light, which enables the pilot to line-up his airplane with the runway, or with the most favorable landing-area on the field. The application of

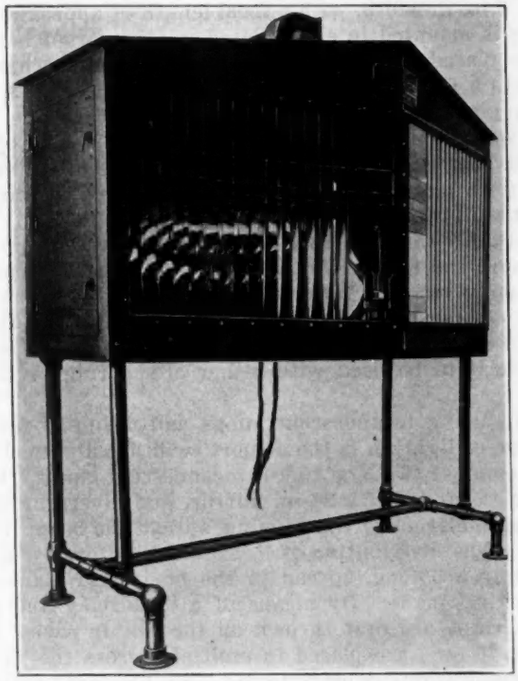


FIG. 5—AIRPORT FLOODLIGHT USING INCANDESCENT LAMPS

This Is Designed for Use with the Centralized System of Lighting Shown in Fig. 9. Two 5 or 10-Kw. Lamps Are Burned in It, Each Lamp Being Placed in the Focus of a 24-In. Mirror. Diverging Glass Strips, Constituting the Front of the Housing, Spread the Beam in the Form of a Fan in the Horizontal Plane

obstruction and approach lights is apparent from the diagrams of lighting layouts described later.

It is sometimes found more practicable to make obstructions visible by floodlighting them, a method that has the added advantage of assisting the pilot in esti-

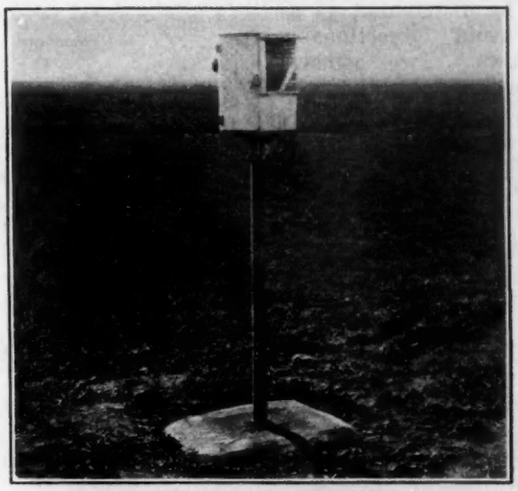


FIG. 6—SMALL 120-DEG. FIELD-LIGHT

This Is Used with the Distributed System of Lighting Shown in Fig. 10 and Consists of a Fresnel Lens, Approximately 8 In. High and Having a 6-In. Radius, at the Focal Point of Which Is Placed an Incandescent Lamp of from 900 to 1500 Watts. A Spherical Mirror behind the Lamp Gathers the Light Rays Thrown toward the Rear and Directs Them in a Useful Direction

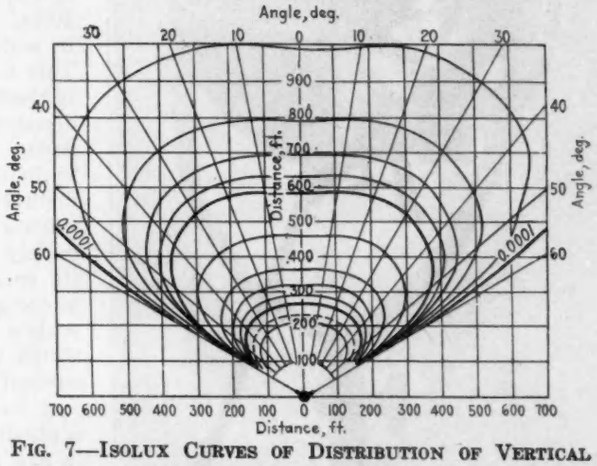


FIG. 7—ISOLUX CURVES OF DISTRIBUTION OF VERTICAL ILLUMINATION FROM SMALL 120-DEG. FIELD-LIGHT

These Curves Are for the Field-Light Shown in Fig. 6 with a 1000-Watt, 115-Volt T-20 Mazda Lamp in Use

mating his altitude. When this system is employed, care must be exercised in locating the floodlighting projectors, so as to avoid glare in the eyes of the pilots.

METHODS OF FIELD FLOODLIGHTING

General illumination of the field is a very important feature of the lighting, for upon it depends the pilot's knowledge of the field terrain. Every facility should be provided to enable pilots to take off, land and maneuver safely, for, with the increasing size of airplanes and the establishment of passenger service, the need of adopting every possible safeguard becomes increasingly greater.

The lighting system of an airport, to be successful, should be adequate in intensity, free from glare, fairly uniform over the entire area of the field, and be distributed so as to avoid objectionable shadows. Two general methods of lighting the field are in use; namely, (*a*) a centralized light-source, consisting of a large unit, and (*b*) distributed light-sources of relatively smaller capacity. Units of the former class are available in

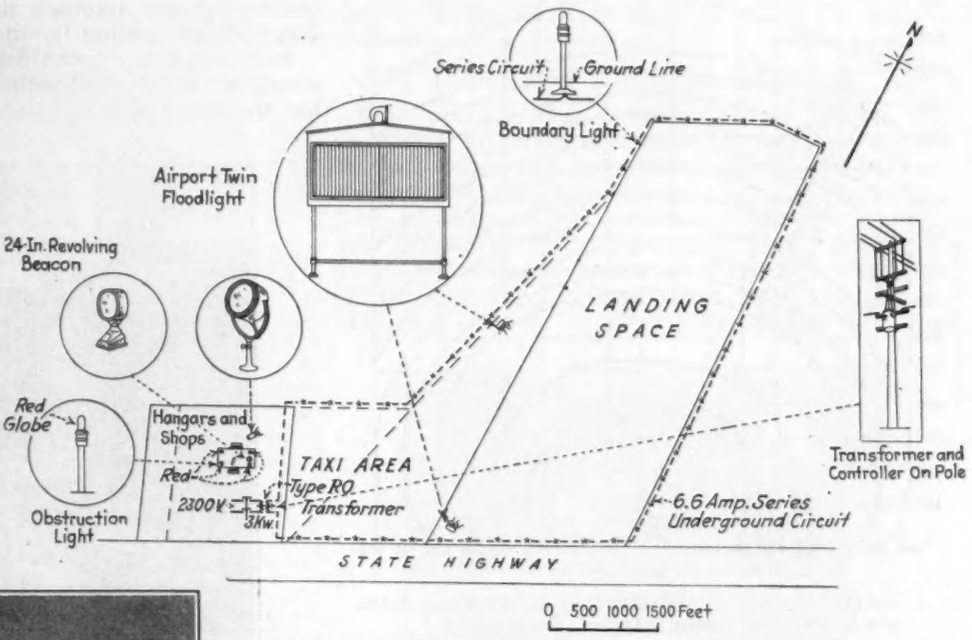


FIG. 9—AIRPORT LIGHTING-PLAN SHOWING THE CENTRALIZED SYSTEM OF FIELD ILLUMINATION

Two Units Are Available, the One That Is Most Favorable with the Prevailing Wind Being Used

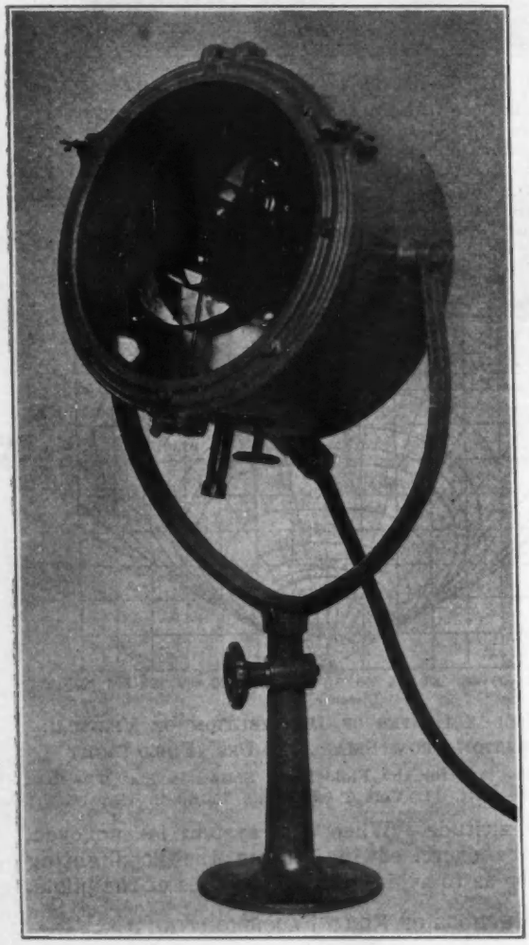


FIG. 8—SEARCHLIGHT USED FOR DETERMINING HEIGHT OF CLOUDS ABOVE GROUND

This Is a 12-In. Incandescent Searchlight and, When Equipped with a 500-Watt, 110-Volt T-20 Mazda Lamp, Delivers an 8-Deg. Beam of 400,000 Cp. The Beam Is Projected at an Angle of 45 Deg. to the Vertical and the Distance Paced Off to a Point Directly Under the Light Spot on the Base of the Cloud Gives the Height of the Cloud above Ground

both the arc and the incandescent types. A typical form of the former is illustrated in Fig. 3 and consists of a 180-deg. sector of a Fresnel lens composed of 21 elements. The lens is 3 ft. 6 in. in height and 4 ft. 8 in. in width, with a focal length of approximately 20 in. The lens is mounted in a ventilated weather-proof housing in which is also placed a 150-amp. high-intensity arc mechanism. This unit delivers a fan of light of approximately 180-deg. spread in the horizontal plane and 2 deg. spread in the vertical plane. The distribution of vertical illumination over the field is shown by the isolux curves in Fig. 4. These curves indicate the illumination in foot-candles on a plane at right angles to the field at varying distances from the unit.

This unit is usually installed in a shed and is elevated approximately 10 ft. above the field. The arc requires direct current for its operation, and, when only alternating current is available, a motor-generator set must be installed. The unit may be equipped with a 10-kw. incandescent lamp, in place of the arc mechanism, which will enable it to be used with either alternating or direct current.

A form of unit using incandescent lamps and designed for the centralized system of lighting is the airport twin floodlights shown in Fig. 5, which employs two 5 or 10-kw. incandescent lamps. Each lamp is placed in the focus of a 24-in. mirror, and diverging glass strips, comprising the front of the housing, spread the beam in the horizontal plane. The distribution of light is in the form of a fan with approximately a 90-deg. spread in the horizontal plane and 6 deg. in the vertical plane. By means of a time-relay and contactors, the two lamps are first thrown on the line in series and, after a period of 30 sec., are placed in multiple across the 110 to 120-volt line. This prevents damage to the lamp filament, which is likely to occur if lamps of this size are subjected to the full voltage at the start.

A form of unit in use with the distributed system of lighting is shown in Fig. 6 and consists of a small 120-deg. Fresnel lens, approximately 8 in. high and having a 6-in. radius, at the focal-point of which is placed an incandescent lamp of from 900 to 1500 watts. A spherical mirror is placed behind the lamp to gather the light thrown to the rear and direct it in a useful

direction. This system of lighting is usually employed for illuminating runways and small fields. The units are generally operated through a transformer from the constant-current boundary-light circuit and spaced on 200 to 300-ft. centers. The illumination of the field in a vertical plane from a single unit is shown in Fig. 7.

All the above systems of field illumination have been found appropriate under certain conditions. A careful survey should be made of local conditions and requirements to determine the most suitable system. Just what intensity of illumination is desirable has not been definitely determined to the satisfaction of all parties concerned, but prevailing practice indicates that average vertical illumination of approximately 0.25 ft.-candles has been found satisfactory. Our experience in this field is relatively limited, but data are accumulating very rapidly and with them definite standards of practice.

Illuminated Wind-Direction Indicator

It is essential that the pilot of an airplane know the direction of the wind on the ground when he is about to land. The customary device used for giving him this information is a cloth cone. At night, this is illuminated by deep-bowl porcelain-enameled steel reflectors arranged on four brackets 90 deg. apart and approximately 6 ft. above the cone. Each reflector is equipped with a 100-watt Mazda lamp. An obstruction light surmounts the wind-cone structure. Other devices are employed to give the pilot information regarding the direction of the wind, but the wind-cone is the most generally used.

Observations of the height of the clouds above the ground, that is, the ceiling, are made at airports and the information is transmitted to interested persons. This is a measure of the visibility from the air and is very useful information. A means of determining this information readily is by a narrow beam of light projected toward the clouds at an angle of 45 deg. Pacing off the distance from the light source to the point directly beneath the spot it makes on the clouds gives the height of the clouds above the ground; that is, the height of the ceiling. Fig. 8 illustrates a 12-in. incandescent-lamp searchlight which is frequently used for this service. When equipped with a 500-watt, 110-volt, T-20 Mazda lamp it delivers an 8-deg. beam of 400,000 cp.

Lighting Layouts

Figs. 9 and 10 indicate typical airports that employ the two systems of field lighting to which reference has been made. That shown in Fig. 9 is equipped with the centralized system of lighting, two units being available and the one being used that is most favorable with the prevailing wind; that shown in Fig. 10 illustrates the distributed system in which the illumination is confined to the runways. The arrangement of boundary lights, obstruction lights, approach lights, beacon, and the like, on these plans is typical of present practice.

THE DISCUSSION

A. Paulus[1]:—While it is common practice to mount the large single lighting-units 8 to 10 ft. above the ground, a mounting height of approximately 30 ft. has been found to cause less glare to the pilot. When

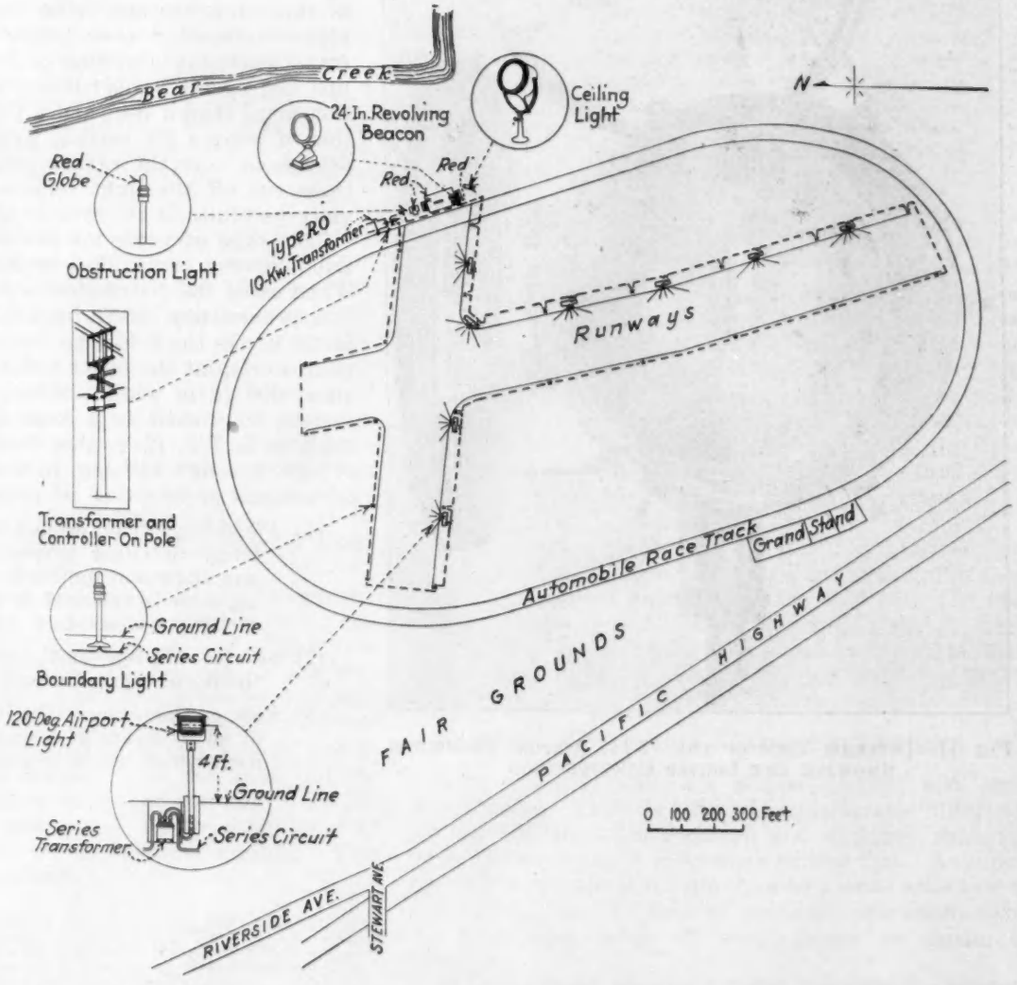


FIG. 10—AIRPORT LIGHTING-PLAN SHOWING THE DISTRIBUTED SYSTEM OF FIELD ILLUMINATION

In This System the Illumination Is Confined to the Runways. The Arrangement of Boundary Lights, Obstruction Lights, Approach Lights, Beacon, and the Like, on the Plans Shown Above and in Fig. 9 Is Typical of Present Practice

[1] Commercial engineering department, Westinghouse Lamp Co., Bloomfield, N. J.

mounted at this elevation, a greater vertical beam-divergence is necessary to illuminate a sufficiently wide area of the field. However, not enough tests have been conducted to warrant the use of high mounting, due to the fact that it is believed that in heavy weather the pilot may have difficulty in distinguishing between the top of the beam and the ground-level.

Mazda incandescent lamps are performing an important rôle in aviation lighting and are being used increasingly for the illumination of landing-fields. For this purpose, lamps ranging in size from 1000 watts to 10 kw. have been developed by the lamp manufacturers and, so that these lamps could be used effectively, suitable reflecting equipment has been designed. One of these designs which is being used rather extensively is the 24-in. airport projector shown in Fig. 11. It is built with a 23-in. paraboloidal reflector and a 50-deg.

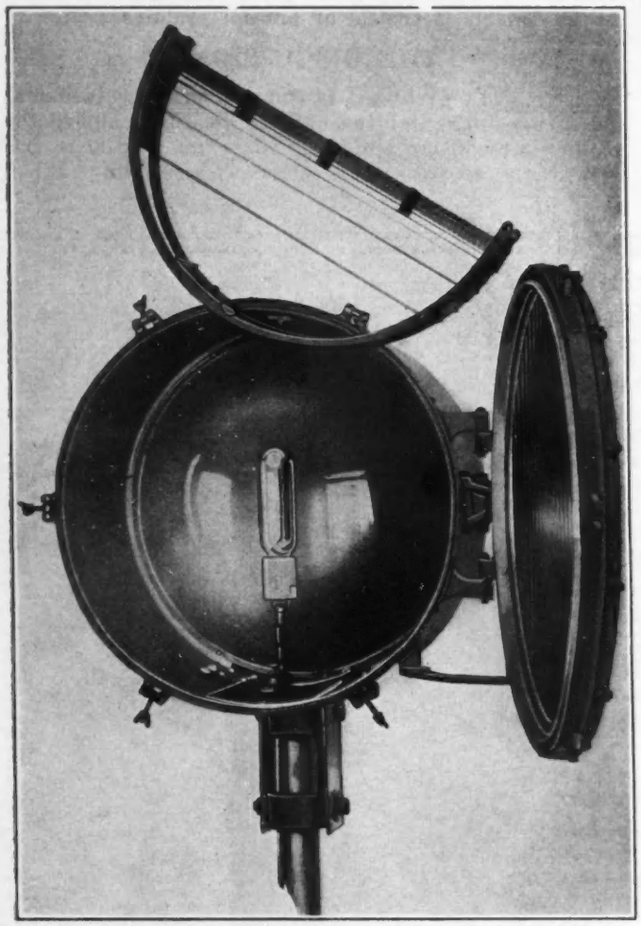


FIG. 11—INTERIOR VIEW OF THE 24-IN. AIRPORT PROJECTOR SHOWING THE LOUVER CONSTRUCTION

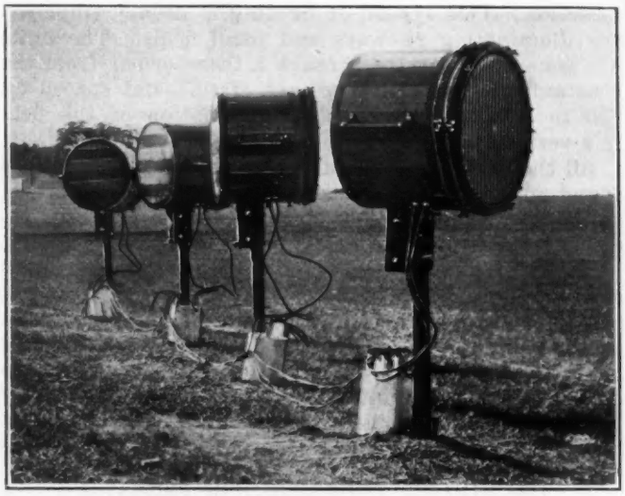


FIG. 12—CENTRALIZED SYSTEM OF FLOODLIGHTING USING THE 24-IN. AIRPORT PROJECTOR

spread lens, and when provided with a 1500-watt 32-volt G-40 Mazda lamp, will emit a beam of more than 300,000 cp. maximum. Other lamps of larger wattage for use in this projector are being developed which will give higher intensities over larger areas. A semicircular frame enclosing a system of louvers and held in place just behind the spread lens prevents any light projection more than 3 deg. above the horizontal. The addition of louvers for vertical light control is a great improvement over the earlier types of projector, in that these cut off the light reflected upward which would glare painfully in the eyes of the descending aviator.

This type of projector can be used in either a distributed or a centralized system of field floodlighting. When using the distributed system, the units are spaced at approximately 250-ft. intervals, with their beams projected across the field; the fan-shaped illuminated areas then overlap at the edges and form a well-lighted path about 600 ft. in width. When used in the centralized system, four units in a bank are arranged in a semicircle as in Fig. 12, so that they produce a total spread of light through 180 deg. in the horizontal plane. The advantages of this type of projector are:

(1) *Flexibility.*—The projectors can be used effectively in either system of field floodlighting and additional units can be added as the landing area is enlarged or as a greater intensity of light is desired

(2) *Safety.*—Multiple-unit installation assures continuity of service in case one lamp fails

(3) *Ease of Operation.*—The lights can be turned on or off by means of a simple switching arrangement which can be located at any desired point

Motorcoach Design

Discussion of K. J. Ammerman's Transportation Meeting Paper[1]

SUCCESS of the motorcoach manufacturer is in proportion to his ability to provide the passenger with a safe, comfortable ride and to provide the operator with an economical, durable and amply powered motorcoach that can be operated at a profit. To do these things, and to build a motorcoach capable of withstanding the severe strains imposed on both chassis and body by the fast schedules now obtaining in many localities, the author explains that motorcoaches must approach steam-railroad passenger-car equipment in weight per passenger.

Developments in motorcoaches parallel those of railroad coaches in many respects and are passing through the same course of evolution. Only a few years ago a standard railroad passenger-car weighed 40 tons, while today a car having no greater passenger-carrying capacity weighs 60 tons. The increase in weight was due to the demand of the traveler for greater speed and to the fact that the light cars would not withstand the great strains and were not safe.

Engineers and manufacturers can improve and have improved motorcoach construction by using better materials and workmanship, but they are limited in this respect by the desire of the operator to buy at the lowest possible initial cost. Superior workmanship and high-grade materials are least visible to the operator where they do him the most good, yet many operators are seeking more and more speed, seeming not to realize that a motorcoach that is safe at 40 m.p.h. may not be safe at 55 m.p.h.

Other factors mentioned by the author as pertinent to good motorcoach construction are simplicity of design, effects of excessive body overhang on efficient operation, distribution of weight as it affects tire cost, factors that determine passenger comfort, the baggage-carrying problem, the value of sturdy appearance in enhancing the confidence of the rider, the economy of standard body-building, and the costs imposed by deviations from standardized design.

In the discussion stress is laid upon the desirability of standardizing drivers' seats and controls so that drivers will not have their attention distracted from the road by differences in manipulation when changing from one motorcoach to another. A letter from a large operator points out respects in which further improvement is desirable. An analysis is given of weight distribution on body and chassis frame. Inadequate bumpers are criticized, and electric transmission is advocated as a solution of the problem of control of the large, fast motorcoach.

CHAIRMAN H. C. CROWELL[2]:—Mr. Ammerman's plea for standardization, I hope, will not go unheeded.

H. L. DEBBINK[3]:—Mr. Ammerman has spoken about the desirability of working toward standardization of bodies and of the vehicle as a whole. The company with which I am connected has been operating motorcoaches since 1919, and each year, during the last 4 or 5 years, we have hoped that we had reached a point where we could standardize on one type. There have been so many changes in general design that this has been impossible so far, but I think there are some details on which we could standardize. These could be taken up by the Society and their standardization would help operators a great deal.

We have a well-standardized course of instructions for motorcoach drivers, and we try to teach them one standard of operation. Whenever we get a group of new motorcoaches that have controls which are different from those of our other vehicles, we have to send out all of our drivers with the instructors so that they can become familiar with that particular type of motorcoach before they can operate it on the lines. In the meantime, until we have made the rounds of all the drivers, we have to assign the motorcoaches to only those routes on which the drivers are trained. This complicates matters somewhat.

The things that bother the driver the most are the controls. Almost every type of motorcoach we buy has a different relation between the driver's seat and the pedals and levers. There are some decided differences, for instance, in the hand brake, some are pushed and some are pulled. In hand brakes of the same type, some are so arranged that a man can operate them readily, while others are so constructed that he has to stretch away out to the side to reach them. In some cases the hand brake is on the left and in other cases it is on the right side. We should reach a standard in that respect.

In our standard operation for stopping, a driver first makes a partial application of his hand brake. He then shifts into neutral and finishes the stop with the foot brake. Where he has to use the hand brake at every stop, if the lever is about 4 in. more to the right than in the usual type of motorcoach, the operation is affected a great deal.

OTHER DIFFERENCES THAT BOTHER DRIVERS

Some steering-posts are almost vertical and some are inclined. There is naturally considerable difference in the way they are operated and a driver changing from one motorcoach to another notices this. Anything making it necessary for him to give special attention to the control, for the sake of standard operation, takes his mind that much off other things he should be watching.

In some cases we get drivers' seats that are right up under the steering-wheel, so that a tall man has his knees drawn up high. I think in every case the driver's seat should be adjustable, or at least should be placed

[1] The paper was published in the December, 1927, issue of THE JOURNAL, p. 653. An abstract of it is printed herewith as an aid to the reader of the discussion, the main points of which are also abstracted. The author is an executive of the American Car & Foundry Motors Co., New York City.

[2] Assistant to chief engineer, Pennsylvania Railroad, Philadelphia.

[3] M.S.A.E.—Superintendent of gasoline vehicles, Milwaukee Electric Railway & Light Co., Milwaukee.

back far enough so that a tall man could operate readily; a short man could use auxiliary cushions.

There is also a great deal of difference in the clutch-pedal pressure required on different types of motorcoach. Some clutches take three times as much pressure to release them as do others. A driver may have two or three-piece runs on a city line. On the first piece of his run he will have one type of vehicle with a pedal that operates easily, and on the next piece he may get a type that operates two or three times as hard. As a result, he is always complaining to the maintenance department about this last type. It seems that if we could decide what is a reasonable pedal pressure we could work to that end.

Even a little thing like the horn button is important. Automobile horn-buttons are almost universally placed in the center of the steering-wheel. Many motorcoaches are built with the horn button either on the driver's seat or in some other place where he can reach it readily. In some cases it is on the dash near the steering-wheel, while in a few cases it is placed under the steering-wheel on the steering-column. I think the location could easily be standardized.

Motorcoach seats, in general, are much more comfortable than those in steam and electric cars but they are too small, and there is not enough leg-room in most cases. We have noticed this especially on some types of operation, like that we maintain between Milwaukee and Madison, Wis. This is almost a 100-mile drive, and passengers are carried about half the distance on our rapid-transit electric line and then transferred to parlor-car motorcoaches, which draw up alongside the parlor-car rail-car and take them on into Madison. In the winter passengers have often commented on the fact that, while both services were excellent, they did not have enough room to sit down in their overcoats when they were transferred from the rail-car to the motorcoach. Passengers are going to be more critical of the motorcoach in all types of service in the future, I think, and we must devote more attention to giving them enough room to sit down in comfort, in addition to giving them a very comfortable seat.

What Is Wrong with Fuel Tanks

It seems that manufacturers do not think about locating a gasoline tank until they have the entire job completed. Then they look around for a place to put it. As a result, they install a tank of any size for which they can find space. Often the tank is too small for the requirements of the average run, and frequently it is of such a construction or so located that the contents cannot be measured, except by means of a gage, and gages are not always as satisfactory as they might be. It often happens on city-service lines that gasoline requirements run within 2 to 5 gal. of the capacity of the tank. If there is any bad-weather condition, such as snow, which would require the use of more gasoline than usual, there is the danger of the operator running out of fuel, and, unless he has some way of measuring the gasoline in the tank, he cannot be held responsible.

Many of the gasoline tanks are so installed that the filler pipes have several turns in them and do not take the gasoline fast enough when filling the tanks. This is especially noticeable in city service. Large numbers of motorcoaches come in at a time; often a string of them is lined up in front of the tanking stations. At all of our tanking stations we have pumps that can deliver between 20 and 25 gal. per min., but I do not believe more than half of our motorcoaches will take delivery at this rate. In most cases the delivery from the electrical pump must be throttled down so that it is filling at the rate of only about 10 gal. per min. This slows-up the work incident to placing the vehicles in the garage at night.

The carriage of luggage has always given a great deal of trouble. The parlor-observation type of motorcoach takes care of luggage nicely, but this type is not suitable for all of our requirements, and in some cases I still think we must continue to use the roof luggage-carrier. We started some years ago with luggage carriers in the rear of the vehicle, but the operating department was always hounding the maintenance department to put auxiliary seats there. After the auxiliary seats were put in, the next step was to install upholstered seats instead, and the luggage carrier disappeared.

On most interurban lines where luggage carriers are needed the driver knows fairly well which are his heavy and which are his light trips. Possibly half a dozen trips a week are heavy. At times only two or three trips a week may be heavy. These are the times when he really has a capacity load and needs the auxiliary seats in the inside luggage-carrier. On such occasions the roof luggage-carrier serves the purpose and permits of carrying four or five more passengers than if the inside carrier were provided exclusively.

CHAIRMAN CROWELL:—Apparently there are other reasons than economy for having standardization in motorcoach bodies as well as in a great many other things.

Standards Committee Considering Many Items

K. L. HERRMANN[1]:—Standardization is limited because of the different types of operation which motorcoaches must serve satisfactorily. Drivers' seating and operation, as suggested by Mr. Debbink, can be standardized readily by specifying the distances from the bottom of the steering-wheel to the seat and seat back; from the back of the seat to the pedals and hand controls; and from the bottom of the steering-wheel to the top of the hand controls, and by specifying the deflection rate of the seat cushions. When this is done, a driver can change from one motorcoach to another and feel reasonably well at home, so that his ability to operate the vehicle will be influenced very little by variations in other details.

As to standardizing head-room and shape of the roof, we feel that for suburban parlor-motorcoach service it is very necessary to have more head-room because of the large number of stops to take on and discharge passengers. Extra head-room in this service more than offsets any disadvantage of which we know. In intercity parlor-motorcoach service, where the number of passengers taken on and discharged is very small, the low head-room is very desirable and the advantage of a low roof seems to more than offset the advantages of the high roof.

The Motorcoach Division of the Standards Committee is in a position to standardize on certain types and details of motorcoaches. Street-car service is very similar throughout the Country and in motorcoaches we might be able to standardize seat heights and widths, the distance between seats, the width of aisles, and the like. These and other items have already been taken up by

[1] M.S.A.E.—Consulting engineer, Studebaker Corporation of America, South Bend, Ind.

the Standards Committee, which is now in process of enlarging the scope of this work wherever it is reasonable to do so.

At present our standards program should be based on the operator's requirements rather than on those of the manufacturer, but, because of the small number of units used in any one type of service, it seems that motorcoach manufacturing must be more or less along custom-built lines.

Improvements Suggested by an Operator

F. C. Horner[5]:—One of the outstanding examples of what is now coming in scientific motorcoach operation in this Country is to be found in Washington, where E. D. Merrill, president and general manager of the Washington Rapid Transit Co., has had a great deal of experience in the operating field. While the Transportation Meeting Committee was considering the question of subjects that would be valuable to discuss, I wrote to Mr. Merrill asking for his ideas. I think it well worth while to read his reply.

> Some of the most difficult matters with which we have to contend would no doubt seem trivial to automotive engineers in comparison with the very difficult mechanical problems that have been taken care of remarkably well in most of the motorcoaches now on the market. I am suggesting several such matters herewith.
>
> *Noise.*—Increasing importance is being attached to the matter of noise. The motorcoach that is going to be accepted in the future will be quieter than those now being sold. The matter of exhaust noises has been well taken care of on some of the vehicles now being made, but the matter of gear noise in first, second and third gear, with fourth-speed drive, has not yet been solved. The gear sing can be heard for a long distance and gives rise to considerable objection on the part of residents near the routes where there are hills of considerable length. This is the strongest argument in favor of the gas-electric motorcoach and, I can imagine, may be a controlling factor in some cases.
>
> Several makers of motorcoaches have not given sufficient attention to muffling devices, with the result that there is considerable exhaust noise which, I am advised, can be eliminated without undue back-pressure on the engine.
>
> *Transmission and Clutch.*—I regard present transmission and clutch design as very unsatisfactory. Noise has been mentioned above. The metal going into transmission gears seems unsuited to the strains imposed upon it. The only answer we can get is that gears are "overloaded." If so, they should be enlarged or made of sterner stuff to stand the service required of them. Possibly a combined clutch and change-speed device on an entirely new principle is required. The gas-electric drive provides this but introduces more weight, complication and expense.
>
> *Carburetion.*—It seems that combustion of the fuel in certain types of motorcoaches is not complete, and the exhaust gases give off noxious odors that cause headaches, not only among passengers but among motorists who may be driving beside the motorcoach in congested traffic. A very unfavorable reaction against motorcoach operation is thus built up, which may prevent extension of lines and even cause cancellation of permits. This condition may be due to improper carburetion or ignition and certainly ought to be corrected.
>
> *Extra Equipment.*—The matter of equipment to be furnished on motorcoaches is becoming a problem. The operator is interested in having low maintenance costs, and from that standpoint wishes to limit the auxiliary equipment and to have such equipment as is provided as simple as possible. On the other hand, equipment that will save operating expense is desirable, and the operator is confronted with the difficult problem of determining what special equipment it will pay to purchase and maintain. This leads to the thought that all accessories, such as lights, mirrors and buzzers, should be incorporated in the body design in such a way as to be an integral part of the body and yet be removable in case of damage.
>
> *Brakes.*—These are, of course, extremely important, and there seems to be much doubt in the industry whether the straight mechanical brake, the booster brake, or the air-brake is the proper one to use. The matter of brake lining is also important and is not yet taken care of satisfactorily. If a mechanical brake could be found that would be lasting, and yet have sufficient braking ability to be used under difficult conditions, thus avoiding the necessity for the use of the booster brake or the air-brake, the industry would benefit very considerably.
>
> *Passenger Movement.*—The movement of passengers within the vehicle and also their entering and leaving it, must be considered more and more, if the motorcoach is to serve the increasing volume of traffic and do any considerable portion of the work usually regarded as street-car work. Various expedients have been tried, such as the rear door with treadle, the wider body with wider aisle, lower steps, and the like, but I believe there is room for some constructive suggestions regarding the body design that will help to speed-up loading and unloading.
>
> *Standardization.*—The standardization of equipment is, of course, extremely valuable to the operator and should help to reduce the cost of the vehicles. It would seem that even with the different types of engine, a greater degree of standardization could be reached in many of the accessories and attachments that go with the engine. Much work has been done along this line, but I believe there is room for more.
>
> *Ventilation.*—The ventilation of bodies, it seems, is not very satisfactory, and I have often heard the remark that motorcoaches are not nearly as cool as street-cars in hot weather. The Buick Motor Co. has solved the matter of ventilation remarkably well, I think, so far as the private car is concerned, by providing an air duct below the windshield which operates only when the windshield is raised. If some such construction could be devised, giving ventilation across the full windshield without the necessity of introducing a hinged lower portion of the windshield, I believe it would be welcomed by all motorcoach operators.

Tests on Distribution of Weight

C. B. Norris[6]:—I am interested in Mr. Ammerman's remarks concerning the distribution of the weight of a motorcoach upon its wheels and the overhang of the body beyond the rear wheels because the company I represent has learned from tests that these two things have a great influence upon the forces exerted by the body upon the motorcoach chassis. One test was made upon a coach with which Mr. Ammerman probably is very familiar—the double-deck type made by the American Car & Foundry Motors Co. for the Detroit Street Railways.

Let us suppose that the body of the usual motorcoach rests upon the chassis at two points only; the first at the rear of the hood some distance behind the front

[5] M.S.A.E.—Assistant to vice-president, General Motors Corporation, New York City.

[6] Mechanical engineer, Haskelite Mfg. Corporation, Grand Rapids, Mich.

wheels and the second directly over the rear wheels. Assume that when the coach is empty of passengers the floor of the body is above and parallel to the chassis frame. When the passengers enter, the body is bent concave upward due to their weight. The chassis frame will also bend concave upward due to the weight of the passengers transmitted to it at the front of the body. The body, due to its great stiffness, will bend a great deal less than the chassis frame, and therefore the vertical distance between the floor of the body and the chassis frame will increase near the center of the body.

Now suppose that the body is fastened to the chassis at several points along its length in the usual way. When the passengers crowd into the coach the chassis frame tries to move vertically downward away from the body and, because it is fastened to the body, tries to pull the body down with it. It holds the body up at its ends but pulls it down at its center. That sounds rather queer but is what actually happens. In the case of a double-deck motorcoach, this downward pull upon the body occurred at the second post and was equal to the entire passenger load. This force is large enough to be considered seriously. It can be overcome by correct load distribution and overhang.

With Passenger Load Over Rear Wheels

Suppose that we decide to design a motorcoach so that the center of gravity of the passenger load is directly over the rear wheels. That does not mean that the rear wheels are necessarily in the center of the body; they may be considerably to the rear of the center, because of the greater number of passengers that can usually get into the rear of the body. In a vehicle of this type the passenger load is supported by the chassis mainly at points over the rear wheels. The supporting force at the front of the body is nearly zero. The chassis frame bends concave downward instead of concave upward and all the outriggers are supporting the body. If the body is six times as stiff as the chassis frame, which is about the average case, six-sevenths of the weight of the passenger load will be carried by the four outriggers, two on each side of the coach nearest the rear wheels. The remaining one-seventh will be distributed among the remaining outriggers.

A test was made upon a body designed by the Lang Body Co. with the foregoing load distribution in view. This test showed that the desired results were obtained upon the right side of the coach, that is, all of the outriggers were supporting the body. On the left-hand side, however, the second outrigger from the front was found to be pulling downward upon the body with a force equal to one-fourth of the total passenger load. The design of the body was such that the offending outrigger was not necessary, so it was removed. The removal of this "support" actually increased the strength of the motorcoach.

Street-Car Type Reduces Concentration

Another design of motorcoach which overcomes this downward pull on the body is so new that perhaps I should not talk about it, especially as I have no tests upon it. It is the street-car type. I was pleased to find Mr. Ammerman's company playing with this type also. The body extends the full length of the chassis and is supported mainly by the eight outriggers nearest the four wheels, four on each side. If we assume again that the body is six times as stiff as the chassis, those eight supports carry six-sevenths of the passenger load, reducing the concentration of the load considerably. Speaking merely with reference to stresses, without considering operating and maintenance conditions, this design is the best I have seen. A light body of this type should stand up under rather severe road conditions.

How Load-Distribution Tests Were Made

The motorcoach upon which we made tests was run over a pit in the factory and a beam of wood, about 5 x 8 in. in cross-section and the full length of the body, was hung from two points of the chassis frame underneath the coach. Cross-arms fastened to this beam carried Ames dials which bore upon the chassis frame in such a way that vertical deflections of the frame could be read. One of these dials was located near each point at which the coach body was fastened to the chassis; it is not necessary to measure the deflection at the exact load point. The more of such dials that are used and the more evenly they are distributed along the chassis frame, the more accurate the results will be.

In the tests we confined our attention to the chassis frame, because we knew fairly well the stiffness of the steel and the shape of the frame section, and, by studying the action of the frame under the forces active upon it, we were able to determine the forces upon the body.

The method employed was to take all the readings of the several deflection meters and plot from them a curve, perhaps one-fourth the length of the motorcoach, showing the deflection of the chassis frame at all points along it. Then a slender wooden beam one-fourth the length of the coach was made having a non-uniform cross-section varying in such a way that the stiffness of the beam at all points was directly proportional to the stiffness of the chassis frame of the motorcoach at corresponding points. By hanging this model beam, by means of a series of rubber bands, in front of the deflection curve of the chassis, attaching the rubber bands to the beam at points corresponding to the points at which the motorcoach body and springs were fastened to the chassis, and varying the tension of the rubber bands, the small model beam could be made to take the shape of the deflection curve of the chassis. Then the length of all the rubber bands was measured, the whole apparatus taken down, and each one of the bands loaded separately until it was stretched to the same length as before. After these loads were measured, it was only a matter of multiplication to determine the loads that caused the chassis frame to deflect. These loads were applied by the body and therefore they are the reactions between the body and chassis.

This test work can be carried on rather accurately. We ran several tests on a motorcoach, duplicated the deflection curves several times, and, applying the theory of probabilities, found that the probable error in our computation was less than 1 per cent.

F. A. Whitten[1]:—Although I am not entirely familiar with the work Mr. Norris has done, I know something about it. The results he has obtained have been borne out by some curious things that have happened. Often one cannot tell what is wrong with a motorcoach because some of the troubles appear where they are least expected. But when a trouble is analyzed carefully, one can usually put his finger on the cause.

[1] M.S.A.E.—Chief engineer, American Car & Foundry Motors Co., Detroit.

The work Mr. Norris has done has been interesting and helpful along this line.

What Is the Desirable Wheelbase?

A. J. Scaife[8]:—We made a survey of the different wheelbases used on motorcoaches, especially on the Pacific Coast, in 1922, and a composite of these different wheelbases was about 200 in. However, to get the correct seat spacing resulted in the design of a vehicle having a wheelbase of 198 in. After we had adopted this as standard and were well into production, the 215-in. wheelbase came into use; and when we were going well in this size, the 230-in. wheelbase was introduced; then, after getting fairly started on this size, the 245-in. wheelbase came into existence. Now I am wondering if someone can tell us how far we are going to go on the single-deck motorcoach; that is, the desirable passenger capacity for this type. Is it 15, 21, 25, 35, 40 or 42 passengers?

Mr. Whitten:—From the operator's standpoint I think 40 is the best. Other things enter into the question, however. Legislation has a considerable bearing on it. Because of congestion in the cities we shall have more of that, and it will be a very decisive factor.

Adequate Bumpers a Difficult Problem

H. E. Barber[9]:—I should like to ask the engineers whether they design motorcoach bumpers for looks or for service. I think this matter should receive serious consideration. At present we see all over the Country motorcoaches that have gone over embankments, and sometimes large ones, due to trivial accidents that could have been avoided by having the proper sort of bumpers. Even a Ford can bump into a motorcoach and push it and all the passengers off the road and over a bank. The railroads would not think of running a train without a pilot to protect the train, but motorcoaches are run with bumpers on only for looks. I think the bumpers should be designed so that if a motorcoach is struck by an automobile it will be protected.

The fenders are placed in such a position that if they are bumped the balloon tires may be cut, and this may throw the motorcoach to the side of the road.

Mr. Whitten:—This bumper matter has been given some thought. The Standards Committee of the Society has discussed the question of location of the bumper. Some of our vehicles have been bumped in the rear by other coaches of our own make and were damaged. We found that the bumpers had not met. Some attempt has been made to correct this condition. We are going to find out whether it is possible to build the front end of a motorcoach so that its front bumper will hit other cars on the bumper. I do not think it possible to build bumpers for motorcoaches that will protect them from collision damage. That would mean rather heavy construction.

I have seen locomotives weighing several hundred tons derailed by a cow. If a locomotive cannot be made to hold to the track if it strikes a cow, I do not know how we can avoid being bumped off by a Ford. I think it is the impact of the vehicle against the motorcoach that causes the accident. When a car going at 45 m.p.h. bumps into anything it is like a projectile. To build a structure that will stand the impact of vehicles of that sort and that an operator can afford to carry around on a motorcoach is a rather difficult problem.

Mr. Barber:—It is not at all difficult; all that is necessary is proper design. No additional weight is necessary.

Limitations of Conventional Control Reached

Guy W. Wilson[10]:—In the last few years we have observed ever-increasing demands on motorcoach manufacturers for a vehicle of greater power per unit of weight, increased seating capacity for a given street space, and lower operating costs per passenger seat-mile. The advent of these requirements has introduced problems pertaining to the economic utility of this greater-capacity vehicle to the extent that practical limitations of the conventional type of control have been reached and, in many instances, exceeded. These circumstances have demonstrated the necessity for an automatic power control embodying rugged construction, reliability and simplicity, with due regard for the popular demand for greater speed, comfort and safety. The electric transmission has demonstrated its adaptability to meet these requirements.

E. S. Stephens[11]:—Improvements in seats and in the observation and baggage-carrying facilities are being made rapidly. One thing, though, that I find rather obnoxious is the fumes from the engine. I do not think the engineers have given this subject proper consideration. Improvements are increasing daily, so that a person can ride in the motorcoaches as comfortably as in railroad trains, and I venture to predict that in the future the motorcoach will be provided with sleeping quarters. I am much in favor of motorcoach transportation for traveling men and for people who like to make short rides to see the country.

[8] M.S.A.E.—Engineer, White Motor Co., Cleveland.
[9] President, Egyptian Transportation System, Marion, Ill.
[10] M.S.A.E.—Engineer, General Electric Co., Schenectady, N. Y.
[11] M.S.A.E.—Sales engineer, Central Commercial Co., Chicago.

Flying through Fog

FOR flying under safe conditions today it is assumed that flying through fog, except for short distances, will not be undertaken. With the perfection of radio direction-finders and the radio beacon, it is today feasible, thanks to the perfection of flying instruments, for an expert pilot to fly between two given points in a fog. The matter of landing, however, is of a more serious nature, and the solution for landing in fog has not yet been found. Research and experimental work is now under way on fog dissipation, fog penetration by rays and instruments to register the airplane's precise elevation from the ground. —Harry F. Guggenheim before New York Railroad Club.

Shock-Absorber Characteristics

By NEWTON F. HADLEY[1]

ANNUAL MEETING PAPER *Illustrated with* CHARTS

AN effort is made to determine the essentials of an ideal shock-absorber and to describe the types that approach or depart from this ideal. Mathematical analysis is not used, but judgment is based on the experience of the author with various types. The requirements of a satisfactory shock-absorber are defined and the methods used by the author in culling out certain shock-absorbers that fail to meet these requirements are outlined.

By means of a machine based on the principle of a steam-engine indicator, the energy required to move a shock-absorber throughout its cycle at varying speeds is measured and charts are obtained. When these charts are compared with a characteristic shape of diagram of a shock-absorber found from repeated trials on the road to give the most satisfactory riding, the merits or shortcomings of any other shock-absorber can be deduced from the difference in shape.

The limits of most shock-absorbers are said to revert fundamentally to a single characteristic termed "range," which is the ability to control a car satisfactorily at high speed on relatively rough roads without interfering with the 20-m.p.h. boulevard-riding that has become so troublesome since the introduction of balloon tires and the attendant changes in spring-suspension.

The various outstanding examples of shock-absorber at present available are classified, roughly described, and their characteristics analyzed. The conclusion reached is that it should be possible to produce a two-way mechanical shock-absorber at a reasonable cost that will give the desired degree of satisfaction, be adaptable to both light and heavy cars, and meet the demands of present-day driving.

SHOCK-ABSORBERS have become of more and more general interest to the car manufacturer each year until they are now considered an integral part of the chassis, as indispensable as a crankshaft is to an engine. To several motor-car manufacturers, this equipment is a bill of expense amounting to $1,000,000 or more per year.

No element of automotive equipment is more difficult to evaluate or to select logically from the various devices offered. As the purpose of a shock-absorber is to produce comfort, satisfactory performance depends, at least in the present state of the art, almost entirely upon the varying opinions of the riders in automobiles. Unfortunately, this performance cannot be expressed in concrete terms, as can speed, acceleration, and hill-climbing ability. For several years manufacturers of automobiles and of shock-absorbers have made a serious study to find a satisfactory means of overcoming this difficulty and of producing a concrete expression for riding comfort, but no satisfactory means of doing so has yet been found and the general methods of selection have been very crude.

It is not proposed to attempt in this paper a mathematical analysis of the requirements of a shock-absorber, but, on the basis of the experience that we have had with various types, an attempt will be made to determine what, in our estimation, constitutes an ideal shock-absorber and to describe generally the types that approach or depart from this ideal. It is hoped by this means to influence producers of shock-absorbers for standard automotive equipment to direct their researches along the lines that seem to us most helpful.

VARIED REQUIREMENTS OF A SHOCK-ABSORBER

A shock-absorber is, first, a device for dissipating the energy of the springs of a vehicle in excess of that which is required to return them to their normal positions after they have been displaced by the irregularities of the road; and, second, a device that will assist in eliminating shimmy, tend to prevent excessive sidesway and, in general, to improve the roadability of the car. These requirements are, undoubtedly, rather broad and considerably diversity of opinion may exist as to the most desirable method of meeting them. New devices that aspire to the title of shock-absorber arrive at our office in a continuous stream. This fact, combined with the limited number of cars available for testing, makes the matter of selection extremely acute. As a result of this situation, it has become absolutely imperative to develop a machine that will aid in the process of elimination.

The first function of a shock-absorber depends almost entirely upon friction, and the magnitude and the disposal of this friction with respect to stroke position or velocity of displacement are important. With these things in mind, we built a rather crude instrument, based on the principle of a steam-engine indicator, to measure the energy required to move a shock-absorber through its cycle at varying speeds, this energy representing the absorptive capacity of the device. From this instrument is obtained a chart on which the abscissas represent the travel of the strap or arm of the shock-absorber and the ordinates represent the resistance in pounds, as measured by a carefully calibrated spring. The area encompassed by this curve is, of course, a measure of the total energy required to move the shock-absorber. The indicator is subject to errors due to the inertia of the moving pencil-carrying arm. These errors, however, do not seem to be serious, for the comparisons are qualitative rather than quantitative.

We have used this instrument closely in conjunction with road work, and through repeated trials have determined in general the characteristic shape of diagram giving the most satisfactory ride. This method has enabled us to arrive at certain general conclusions regarding the shape of the diagram that serve the purpose of reducing the number of shock-absorbers with

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which it is desirable to continue investigation upon the road.

Our method of investigation has, in general, been the following. First, a desk analysis is made of the various devices presented. If this analysis shows that a shock-absorber has indications of merit, charts are taken on the indicator at varying speeds and strokes to show the general characteristics of the device. If the evidence of the charts also is satisfactory, the device is put upon cars on the road and is sent through the usual paces commonly used by all automobile manufacturers and, finally, is allowed to remain on as large a number of cars as are available for life tests, to determine the necessity for readjustment and to discover other difficulties, such as noise, that may develop. In some cases, in addition to the foregoing work, the shock-absorbers are put on break-down machines and are tested to determine their probable length of life.

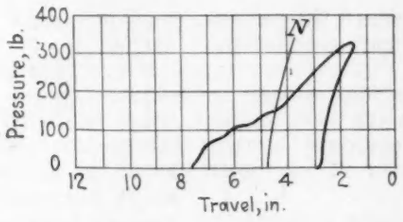


FIG. 1—CHARACTERISTIC OF STRAP-AND-DRUM-TYPE ONE-WAY SHOCK-ABSORBER

This Diagram Is Similar to Those Produced by a Steam-Engine Indicator. The Abscissas Represent the Travel of the Shock-Absorber, in Inches; the Ordinates Represent the Resistance Pull, in Pounds. The Area Encompassed by the Curve Is a Measure of the Total Energy Required To Move the Shock-Absorber. In This Characteristic, the Control After the Frame Has Left the Axle at the Beginning of the Rebound Stroke Is Shown at the Extreme Left; the Force That Would Be Obtained in the Shock-Absorber After the Rebound Has Progressed 2 In. Above the Normal Height of the Car Is Shown at the Extreme Right

One of the greatest difficulties in ascertaining the relative merits of several shock-absorbers lies in the adjustment and its adaptability to the spring-suspension of the car under test. Here good use can be made of the indicator, for, after the characteristics of a shock-absorber that will give a satisfactory ride on a particular car have been determined, it is fairly easy to determine whether other devices in question can be adjusted to give approximately the same diagram.

The limits of most shock-absorbers seem to revert fundamentally to a single characteristic that might be termed "range." Range, briefly, is the ability to control a car satisfactorily at high speed on relatively rough roads without interfering with the 20-m.p.h. boulevard ride that has become so troublesome since the arrival of balloon tires and the attendant changes in spring-suspension. This characteristic limit is more pronounced with respect to the rear shock-absorbers, for a tight rear-adjustment is even more inclined to jiggle a front-seat passenger than is a tight front-adjustment.

As a quick method of determining range, instruments may be checked with increasing control until the performance at 20 m.p.h. becomes objectionable. From the standpoint of all-round desirability, this is the limit of control that may be had. If the car is then tested at higher speeds and over rougher roads, reasonably satisfactory determination of its range may be obtained. Should the control thus obtained on smooth roads prove insufficient on rough roads, the range is not great enough.

Application of this method of testing over a period of years to the principal shock-absorbers available on the market has enabled us to obtain a fund of information from which certain general conclusions may reasonably be drawn as to the ideal type of shock-absorber. To give some idea of our method of arriving at this ideal, we shall endeavor to classify and roughly describe the prominent types of shock-absorber at present available, discussing their merits or shortcomings as the case may be.

Shock-absorbers are of two general classes, the so-called one-way and the two-way types. In one-way devices, the control of spring activity occurs only during the rebound period. Such devices are attached rigidly to the frame and their moving parts are actuated by a strap hooked to the axle, the rewind being taken care of by a spring.

The general objections to all one-way devices with which we are familiar are somewhat as follows: First, the rewind spring is a necessary evil, having a stiffening effect on the vehicle suspension, which, if desirable, would be built into the springs. This has what is sometimes described as a preloading effect, that is, a slight tendency to compress the springs, which is objectionable under boulevard-ride conditions. The result is that no motion will take place in the spring-suspension until the force imposed by the road has overcome the effect of the preloading.

A concrete example of the effect of this condition can easily be had by noting the amount of force necessary to start the spring in motion on a car equipped with preloading shock-absorbers. In all probability this force will be from 100 to 200 lb. before any spring motion occurs. Part of this resistance is friction and part preloading. On the other hand, from 15 to 20 lb. on the shoulder of a passenger will start him bobbing on the seat-cushion. It is obvious that road forces insufficient to move the springs and not absorbed by the

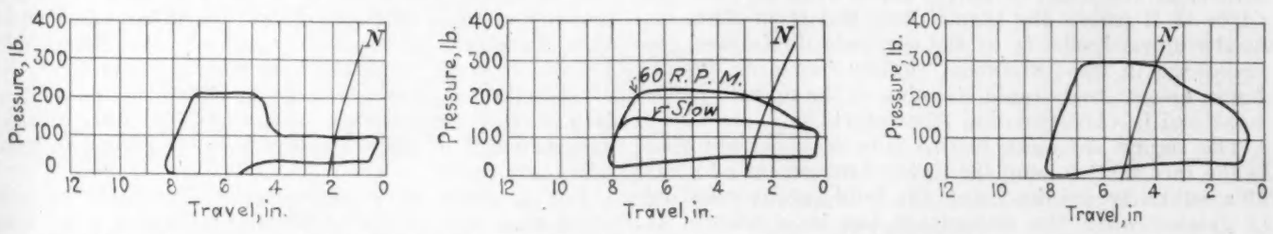


FIG. 2—CHARACTERISTICS OBTAINABLE IN REAR SHOCK-ABSORBERS OF THE PROPORTIONATE-CONTROL TYPE

That Illustrated at the Left Has a 200-Lb. Control at the Spring-Compression Position and Diminishes to 50 Lb. at the Normal Spring-Height. Shock-Absorbers Giving Such a Characteristic Should Afford Good Rough-Riding Control and the Minimum Resistance under Boulevard Conditions. In the Center Diagram the Tendency in This Direction Is Not Sufficiently Marked to Be of Much Benefit. The Characteristic Shown in the Diagram at the Right Is That of the Proportionate-Control Type of Shock-Absorber as Applied at the Front. The Tendency Toward Diminishing Control Is Not Particularly Marked, Although a Slight Approach to the Desired Condition Is Obtained, as Can Be Seen at the Right in This Diagram

tires will come straight through and disturb the passenger, sometimes uncomfortably, thus in part creating the jiggle with which we all are familiar.

This condition is not necessarily serious enough to be readily detected in testing work on the road, as the effect of preloading may be partly overcome by the resiliency of the tires and the action of the seat cushions.

The second and more serious complaint that might be registered against one-way devices has to do with the lack of control of the compression stroke of the vehicle spring.

We believe that a majority of car manufacturers will agree that, because of the light springs in rather general use, the complaint of "bottoming" is becoming serious enough to receive consideration. The marked tendency to reduce car heights by cutting down spring clearance is not helping the situation, and the indications are that shock-absorbers must be used as a natural means of building up a gradually increasing resistance that will keep the car frame off the axle under bad road-conditions.

Classification of One-Way Type

One-way shock-absorbers may be divided under two major headings: (*a*) those depending upon mechanical friction for their resistance and (*b*) those depending upon hydraulic friction. The mechanical type can again be subdivided into three classes, dependent upon their individual frictional characteristics; namely, (*a*) those in which the resistance increases from a small to the maximum value as the spring rebound progresses; (*b*) those in which the resistance decreases from the maximum at the beginning of the rebound to the minimum at the end; and (*c*) those in which the resistance is approximately constant, or slightly increasing, throughout the rebound stroke. Of these types, the second seems to be the most desirable.

The first, or increasing-control type, has one serious disadvantage because the decelerative effects of upward body-movement resulting from this type of control are uncomfortably violent and tend to approach the condition obtained with a too short rebound-strap between the frame and the axle, giving the passenger the impression that the seat has been jerked from under him. Assuming the movement of the car body to have a certain definite periodic motion that describes in general the sine curve, and considering the period of sine motion from the bottom of one wave to the top of the following wave as representing the rebound period, the first type of shock-absorber described will have no control at the beginning of this phase, will have medium control at the point of maximum velocity on the sine curve as it passes the normal line, and from there on, as the upward velocity of the car body diminishes, the resistance in the instrument rapidly increases, resulting in an extremely rapid stopping of the upward movement and in corresponding discomfort.

The second objection to this type of shock-absorber is the fact that, to stop the upward movement of a car at a relatively definite point, the total energy required is greater when the momentum has been allowed to build up, as is the case when this type of control is employed.

This general class includes a large number of strap-and-drum-type one-way shock-absorbers that are on the market. Its characteristic is the simplest to obtain, as it results from the combination of a constant friction-medium and a high-rate, rapidly building-up return-spring.

Fig. 1 is indicative of the characteristic of this particular type of shock-absorber. The control after the frame has left the axle at the beginning of the rebound stroke is shown at the extreme left; the force that would be obtained in the shock-absorber after the rebound has progressed 2 in. above the normal height of the car is shown at the extreme right. The rapidly building-up resistance is clearly depicted and the lack of control at the start of the rebound stroke is sharply brought out. Furthermore, it should be noted that, at the point of the normal height of the car, there is approximately 200 lb. of control in the shock-absorber, which is objectionable for the boulevard ride.

Advantage of Decreasing Resistance on Rebound

The second type of one-way shock-absorber, in which the disposition of the friction is reversed from that of the first type, that is, the resistance of the device diminishes as the rebound progresses, seems theoretically to be far more desirable; and this is borne out to some extent in practice. In this type, the degree of control is roughly proportional to the energy stored in the spring for any spring position. As the energy of the spring diminishes from the maximum compression to the maximum rebound, the controlling energy in the shock-absorber likewise diminishes, making for a much more gentle stoppage of the upward movement and considerably greater comfort for the passenger. Furthermore, comparing these two types of device from another standpoint, it seems that the so-called free center, which has had so much study and discussion lately, would be benefited by the second type, for the excess energy in the spring would be nearly dissipated by the time the vehicle has reached its normal height; hence, at this point, the control in the shock-absorber could be light. This feature is highly desirable in overcoming the jiggle experienced on boulevards at low speeds, as light control at normal height will allow unhampered short spring-movements and allow the wheels to follow more nearly the contour of cobble-stones or similar surfaces.

The principal fault with this type of control seems to be the difficulty of creating a design that will actually fulfil this condition. At present a number of shock-absorbers are available commercially that show a tendency in this direction, but, insofar as we are familiar with them, none has a sufficiently rapid falling-off of resistance to give nearly the most desirable characteristic.

Manufacturers of shock-absorbers recognize more or less generally the basic advantages of this principle, and considerable development work is going on to make this characteristic more pronounced. We thoroughly believe, however, that the best shock-absorbers of the strap-and-drum type are those in which this characteristic is most accentuated, assuming that other things, such as length of life, waterproofness, and freedom from noise, are equal.

Fig. 2 shows the characteristics obtainable in rear shock-absorbers of the proportionate-control type, that illustrated in the diagram at the left being by far the best example, showing a 200-lb. control at the spring-compression position and diminishing to 50 lb. at the normal spring-height. Shock-absorbers giving such a characteristic should afford good rough-road control, with the minimum resistance under boulevard condi-

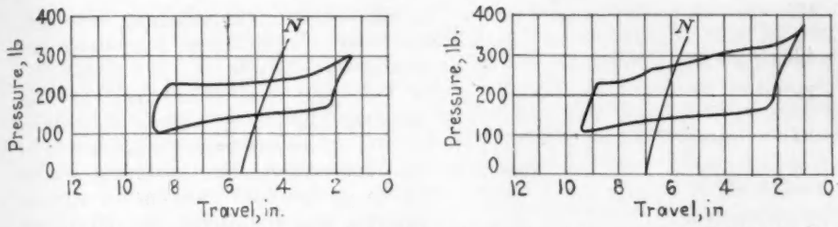


FIG. 3—CHARACTERISTICS OF A SHOCK-ABSORBER IN WHICH THE CONTROL IS APPROXIMATELY CONSTANT THROUGHOUT THE STROKE

Height of the Entire Diagram at the Left Above the Base-Line, Representing Pressures of from 75 to 125 Lb. per Sq. In., Indicates the Amount of Preloading. In the Diagram at the Right the Total Control Has Been Increased and the Amount of Preloading Cut Down

tions. The center diagram shows a tendency in this direction but it is not sufficiently marked to be of much benefit. The diagram at the right shows the characteristic of the proportionate-control type of shock-absorber as applied at the front. The tendency toward diminishing control is not particularly marked, although a slight approach to the desired condition is obtained.

CHARACTERISTIC OF CONSTANT-CONTROL TYPE

A third class of strap-and-drum-type one-way shock-absorber falls between the two classes described. In this type the amount of control is approximately constant from one end of the stroke to the other. The characteristic of this type of device will naturally fall approximately midway between those of the two other types and needs no further discussion. A characteristic of this kind is ordinarily obtained by using a constant-friction medium and an extremely low-rate return-spring, or by a slightly diminishing friction and a low-rate spring. The latter type probably has the greatest following at present, more devices being available today that would fall within these limits than within either of the other two.

Fig. 3 shows results that are typical of the third type of mechanical friction one-way control. The amount of control throughout the stroke is essentially constant. In the diagram at the left, however, the height of the entire diagram above the base-line, representing pressures of from 75 to 125 lb. per sq. in., indicates the amount of preloading existing in the particular shock-absorber. The effect of this has previously been described. In the diagram at the right the total control has been increased and the amount of preloading cut down. The limit in this direction is reached when the device will not rewind sufficiently fast.

The foregoing comments on the types of mechanical one-way friction-devices have been confined entirely to the nature and disposition of the friction; that is, what might be termed the characteristic of the shock-absorber. Many other details, of course, enter into the selecting of particular shock-absorbers of any of these classes. These details relate more to the manufacture and the design than to the basic principle of the instrument. For instance, the operation of these shock-absorbers must be quiet, the life considerable, freedom from the necessity for readjustment is highly desirable, and the possibility of ready means of adjustment to meet the demand of the car-buyer is also rather essential.

The other major division of the general one-way type of shock-absorber comprises the hydraulic device, which is in a class that has recently become very popular and deserves considerable consideration.

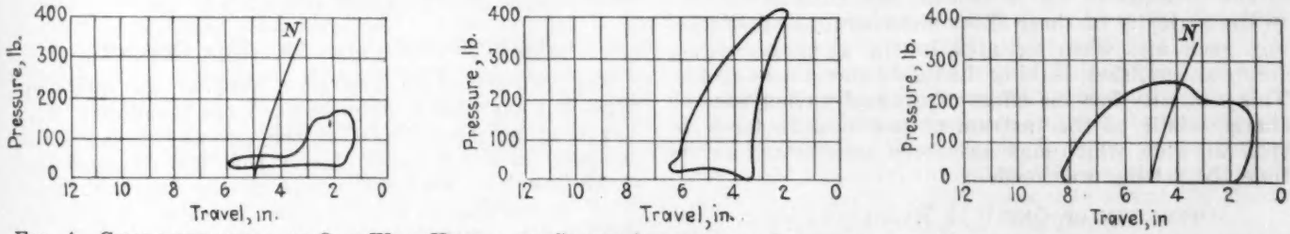


FIG. 4—CHARACTERISTICS OF ONE-WAY HYDRAULIC SHOCK-ABSORBER AT DIFFERENT AIR TEMPERATURES AND AMOUNTS OF CONTROL

The Left Diagram Was Made at an Atmospheric Temperature of 70 Deg. Fahr. and Exemplifies Well the Lost Motion That Results in Lack of Control Until the Rebound Has Almost Reached the Normal Height. The Center Diagram, Made at a Temperature of 6 Deg. Fahr., Demonstrates the Increase of Holding Power with a Reduction of Temperature of about 65 Deg. The Diagram at the Right Indicates the Amount and the Characteristic of Control Sufficient To Hold the Front of a 4500-Lb. Car

The chief objections to this class apply, in general, to all hydraulic friction shock-absorbers. Among these is the rapid variation of the viscosity of any available fluid with the working temperature and the atmospheric conditions, and the fact that the resistance to movement of the shock-absorber is in some measure pro-

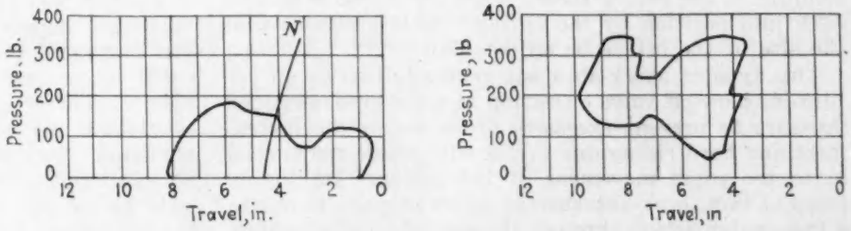


FIG. 5—CHARACTERISTICS OF ROTARY AND RECIPROCATING TYPES OF TWO-WAY HYDRAULIC SHOCK-ABSORBER

Because of the Changing Velocity-Effect of the Testing-Machine, Which Is Somewhat Analogous to the Actual Conditions on a Car, the Free Center Seems, in the Diagram at the Left Taken from the Rotary Type, To Come Above the Normal Height. Only One-Half of the Diagram Appears. The Characteristic of the Return Stroke Would Be Identical with That of the Rebound, Except That It Would Have a Lower Value. The Diagram at the Right, from the Reciprocating Type, Shows Easy Control at the Start of the Rebound, a Marked Free-Center Condition, and the Building-Up of Control Again as the Vehicle Frame Rises Above the Normal Height

portional to the viscosity of the fluid.

The second inherent characteristic of a hydraulic device is both an advantage and a disadvantage and has to do with the fact that the resistance to movement of a fluid through an orifice is proportional to the square of its velocity. In controlling large movements of the car body, this factor is an advantage, for, reverting again to the sine-curve description of body movement, the maximum control at the point of maximum velocity diminishes with the velocity to the top of the swing. On the other hand, this same characteristic becomes a decided disadvantage when the car is traveling over choppy or rough cobble-stone pavements. Here, a high rate of axle movement is desired and the tendency toward building-up control lends a rigidity to the spring suspension that causes discomfort and extreme difficulty in keeping the chassis and the body parts tight and free from rattling.

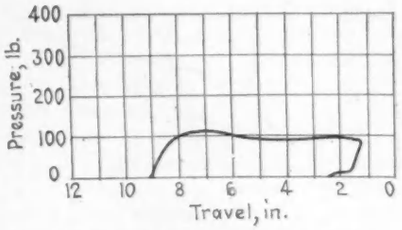


FIG. 6—CHARACTERISTIC OF CONSTANT-FRICTION TWO-WAY SHOCK-ABSORBER
This Diagram Is Self-Explanatory

Other objections to the hydraulic shock-absorber concern the leakage resulting from the effort to confine fluids under high pressure, the expense resulting from the precise manufacturing methods required, and the occasional necessity for replacing the fluid.

The presence of air is also an objectionable feature in the majority of these shock-absorbers, as apparently any such air, when agitated in the presence of oil, forms an emulsion, making the fluid more or less elastic. This elasticity has the effect of gradually changing the characteristic of the instrument and usually tends to spoil the ride, which may have been satisfactory at the time the setting was made.

OPERATION OF ONE-WAY HYDRAULIC TYPE

Most one-way hydraulic shock-absorbers that have had much commercial success are in general similar, consisting in the main of a piston, operating vertically in a cylinder, that is actuated by a crank-arm and is returned to its original position by a spring, the movement of the crank-arm being determined by a strap extending from the end of the crank to the axle of the car. The piston in its downward movement in the cylinder forces oil through a restricted orifice, usually at the lower end of the cylinder, into a reservoir in which a surplus supply of oil is carried. There is usually a one-way valve in this cylinder to allow ready refilling on the return stroke when the piston is pushed back into position by the spring. It is desirable that the size of the orifice be adjustable.

This type of shock-absorber generally carries an adjustable blow-off valve operating at some predetermined pressure to prevent excessive pressures in the instrument and hard riding due to viscosity above the normal or to too rapid movement of the piston. In certain types of this shock-absorber an effort is made to obtain a free-center action through the use of an air-cushion. This method seems to be objectionable, as the air does not remain in a stratified condition but almost immediately emulsifies with the oil and tends to give an elastic action throughout the entire stroke, rather than a free-center effect. Some effort has been made to vary the size of the bypass in accordance with the position of the piston in the cylinder. A free-center action might thus be obtained and possibly give a better characteristic. To our knowledge, however, nothing of this kind has been entirely successful.

The principal advantage of the one-way hydraulic type of shock-absorber, as compared with the one-way mechanical friction type, seems to lie in freedom from noise and in general dependability. In these two respects the hydraulic type has a definite advantage. There is also an indefinite quality that might be termed "smoothness," which, in a properly adjusted hydraulic type of instrument, is more or less noticeable in operation.

Fig. 4 represents two diagrams, at the left and center, taken on a typical one-way hydraulic shock-absorber. That at the left was made at an atmospheric temperature of 70 deg. fahr., whereas the diagram at the center was taken at 6 deg. fahr. In the former the lost motion causing lack of control until the rebound has almost reached the normal height is well exemplified. That at the center brings out strongly the fact that a reduction in temperature of approximately 65 deg. will increase the holding-power of the shock-absorber about 350 per cent. The card at the right indicates diagrammatically the amount and characteristic of control of a one-way hydraulic shock-absorber sufficient to hold the front end of a 4500-lb. car.

TREND NOW TOWARD TWO-WAY DEVICES

The earliest shock-absorbers were of the two-way type, but they have never reached the popularity that has been accorded those of the one-way type. Cost probably is the principal factor that has retarded the development of shock-absorbers of the two-way type. This is necessarily high because a rather expensive linkage for connecting the crank-arm to the axle must be employed. Finally, as most vehicles, at least up to the present, have been suspended on rather stiff springs, the interference of the two-way shock-absorber with the flexibility of the springs, that is, the tendency apparently to stiffen the ride, has also been a factor.

Today, however, the tendency is to look with approval on the two-way type, possibly because several years of experience with a number of one-way types have given the opportunity to prove their inherent difficulties. The recent adoption of a two-way shock-absorber by our best-known manufacturer of small cars will also doubtless go a long way toward furthering their development.

The two-way type has certain undeniable advantages. The most important of these is the ability to prevent the car from striking through on the axle. If this could be accomplished, combined with a comfortable ride, buyers of automobiles would undoubtedly be appreciative, for complaints of this trouble have been persistent for several years. This condition can be accomplished very well, even at high speed over particularly bad roads, by the use of a two-way control and the attendant alterations in the springs that have been found most desirable. To accomplish this result satisfactorily with one-way control, the spring must be stiffened, producing undesirably rapid body-periods and discomfort under bad road-conditions.

CHARACTERISTIC THAT GIVES RIDING COMFORT

The improved state of the roads during the last few years has been more than offset by the greatly in-

creased average driving-speeds, which in themselves form one of the strongest factors pointing toward the ultimate need of the two-way type of shock-absorber. As further evidence in this direction, note the situation in Europe, where hard driving is the rule and the two-way type of shock-absorber is by far the more generally used. Adequate two-way control goes further toward creating roadability at high speed than any other single factor.

The next important factor again has to do with the soft spring-suspension at present in use, and is the marked decrease in side-sway that can be accomplished with effective two-way control. The general characteristic of the ride has a decided difference, which I believe could be established as an improvement, in the judgment of most critics. It will generally be found that, with a properly adjusted two-way control, there is a considerable vertical body-movement, as the car passes over the road, that is a smooth and comfortable swing, whereas, with most examples of one-way control, the tendency is for the shock-absorber to reduce the reactionary body-movement from the springs and to create a less smooth and more jerky effect.

It is customary for engineers, in studying the ride of various cars, to note this condition by commenting on the movement of the radiator-cap, some being particularly impressed by its lack of movement. In our experience, the lack of movement of the radiator-cap seems always to be combined with a jerky harsh ride, whereas a gentle vertical swing of the front end of the car may accompany perfect comfort. This condition is generally experienced with two-way shock-absorbers, but it is secured only by proper adjustment. We have noted in many instances a tendency to adjust the two-way shock-absorber too tightly, in an endeavor to get the same characteristic riding that is ordinarily obtained with the one-way shock-absorber.

The Most Desirable Characteristic

The general subject of two-way control should be further subdivided into the major divisions, (*a*) hydraulic and (*b*) mechanical friction. The general objections to the two-way hydraulic type are, on the whole, the same as those to the one-way hydraulic type and are based largely on the characteristics of fluid friction, which are not too well adapted to the purpose of a shock-absorber. The advantages of the hydraulic two-way type are similar also to those of the one-way hydraulic type, the principal one being its ability to obtain any desired degree of resistance at any point in the stroke, so that, if a desirable curve of shock-absorber resistance plotted against the stroke can be determined upon, the curve for any given velocity can be obtained with the two-way hydraulic shock-absorber.

The most desirable characteristic of a two-way shock-absorber would be generally adaptable to either the hydraulic or the mechanical-friction type. Such a characteristic should start with comparatively low resisttance at normal spring-height, increase with the general form of a parabolic curve as the spring is compressed to the bumper and build up sufficiently at the end of the stroke to prevent striking through. The same characteristic should be duplicated on the return stroke from the bumper to the normal height, in this way dissipating to a large extent the excess energy in the spring by the time the car body has again reached its normal height. The characteristic of resistance may then build up again, as the rebound continues above the normal height to prevent too high an ultimate throw. The resistance should be low on the return from the maximum to the normal height, thus completing a cycle.

Such a characteristic has been approached by building actual equipment, both hydraulic and mechanical, and invariably has given satisfactory results. The front and rear shock-absorbers of a given car may have the same general characteristic, varying only in degree and rate of curvature, the low control at normal height being more important in the rear device to avoid a jiggly ride at low speeds over boulevard pavements, whereas the control at normal height in the front device may be considerably higher, for in this way a certain aid is obtained in overcoming shimmy.

Hydraulic Two-Way Shock-Absorbers

These devices are either (*a*) rotary or (*b*) reciprocating in type, the former being the more common in actual commercial use, although considerable development of the reciprocating type is taking place. This type lends itself more readily to the development of a characteristic such as has already been described. On the other hand, the reciprocating type is ordinarily not so compact and presents difficulties from the standpoint of lost motion in the parts. The rotary type generally operates at considerably higher fluid-pressure than the reciprocating type; consequently, the nature of the medium used is limited to fluids suitable for withstanding high pressures. These fluids, in turn, do not show as desirable viscosity characteristics as can be obtained with the so-called refrigerator oils commonly used in the two-way reciprocating instrument.

Cost has been one of the greatest hindrances in the commercial development of two-way hydraulic shock-absorbers, and it can readily be seen that the cost must hinge largely upon the required precision of manufacture. This difficulty is considerably more pronounced in shock-absorbers of the high-pressure type, in which the piston areas are relatively small and the fixed clearance and the tolerances become relatively more important. For a given amount of resistance in the shock-absorber, these tolerances can be increased more or less as the area of the piston-head increases, which factor is somewhat in favor of the reciprocating type. The required conditions covering adjustment, pressure relief, excess-fluid reservoir-capacity and stuffing-box design for preventing leakage offer very much the same

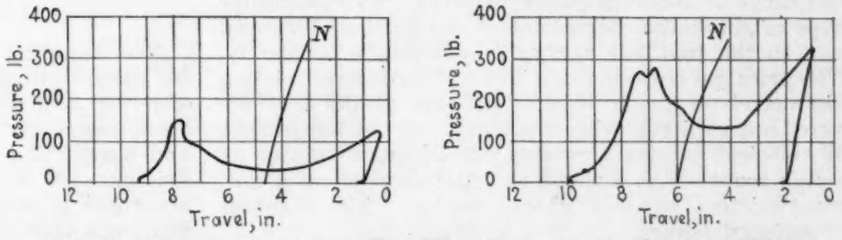


FIG. 7—CHARACTERISTICS OF TWO-WAY MECHANICAL FRICTION SHOCK-ABSORBERS

The Characteristic Shown at the Left Is That of a Rear Shock-Absorber, and the One at the Right Is That of a Front Shock-Absorber. The Latter Shows That the Control Varies from as Much as 325 Lb. at Both the Maximum-Compression and the Maximum-Rebound Positions to as Little as 125 Lb. for Boulevard Riding

problem in both types of instrument. The greatest difficulties yet to be overcome in designs of this kind concern the sufficiently free action of small spring-movements, means for overcoming the effects of fluid viscosity-changes and temperature-changes, and still further development in overcoming leakage. Sufficient impetus seems to be behind this work at present to justify expectations of considerable improvement in the near future.

Characteristics of Rotary and Reciprocating Types

Fig. 5 shows, in the left diagram, the characteristic of a good two-way hydraulic shock-absorber of the rotary type. Because of the changing velocity-effect of the testing-machine, which is somewhat analogous to the actual conditions on a car, the free center appears to come above the normal height. Unfortunately, as our testing-indicator was built to record one-way shock-absorbers only, when two-way instruments are used, only one-half the diagram appears. The diagram of the return stroke, however, would be identical in characteristic with that of the rebound except that it would have a lower value, that on this particular shock-absorber being from 20 to 30 per cent of the recorded resistance.

At the right in Fig. 5 is a diagram of a two-way hydraulic shock-absorber of the reciprocating type. This diagram, having been made on a different indicator, is complete and shows the effect of both strokes. The general characteristic shown is rather favorable, there being easy control at the start of the rebound, a marked free-center condition, and the building-up of control again as the vehicle frame rises above the normal height. Control on the compression stroke is reduced to a value that will tend to prevent bottoming, without sharply interfering with the softness of the ride.

Possibilities of Mechanical Friction-Type

Two-way mechanical shock-absorbers seem to hold considerable possibility for the future. Developments of them should be possible that will afford all the advantages of two-way hydraulic shock-absorbers without the attendant difficulties that seem to be inherent in the hydraulic type. Price and weight are both materially in favor of the mechanical type; and designers of shock-absorbers should exercise their ingenuity in developing a mechanical means of obtaining the characteristic generally accepted as most suitable. The two-way mechanical types at present available commercially divide themselves into (*a*) the constant-friction type, (*b*) the self-energizing internal-brake type, and (*c*) the cam-actuated type.

Commonest among these is the constant-friction type, in which the degree of friction is uniform throughout the range of travel in either direction. This particular type of shock-absorber is one of the earliest developed and in the past has attained considerable popularity. The principal objection to it lies in the constant-friction characteristic itself, which invariably results in a severe boulevard ride when the tension on the adjustment is sufficient to give anything like adequate control on rough roads. Fig. 6 shows the characteristic of a constant-friction two-way shock-absorber. The diagram is self-explanatory.

The self-energizing internal-brake type has a slight advantage over the constant-friction type because, on account of the self-energizing characteristic, the tendency is toward a free-center action at any point where a reversal of motion occurs; hence, for very small spring-movements, practically no resistance will be built up. On the other hand, such shock-absorbers cannot be built so compactly or equipped with so ready adjustment as can those of some other designs. The self-energizing type furthermore has a secondary frictional characteristic that varies more or less uniformly with the speed of movement. Just how important this factor may be, we do not feel prepared to state.

Cam-Actuated Type the Most Promising

The greatest possibilities for further development seem to lie in the cam-actuated type of two-way mechanical friction shock-absorber. With this type a characteristic similar to that previously described can be obtained. It has one drawback, however, that should, if possible, be overcome. This is due particularly to the variation in energy-absorbing capacity that depends on whether the cam device is rising or falling. For instance, the required building-up characteristic, as the spring compresses from the normal height to the bumper, can readily be obtained, but on the return through this stroke the tendency is for the energy to fall off because of the reversal of the action of the cam. This effect is not entirely desirable but is not serious, and instruments made in this manner have given good results as regards ride and the elimination of side-sway and shimmy.

One of the important problems with all two-way shock-absorbers is the linkage from the instrument to the axle. In high-priced devices, the ball-and-socket drag-link type of hook-up has been resorted to, but this is extremely expensive, requires lubrication, and is subject ultimately to rattle-producing wear. Some ingenious methods of overcoming this difficulty have been developed recently by various manufacturers of shock-absorbers, and the use of rubber in the universal-joint ends of the connecting-rod seems to show possibilities of overcoming it, provided the desired length of life of the rubber can be obtained.

Fig. 7 shows characteristics from which very good riding has been obtained with two-way mechanical friction shock-absorbers. Here again only one-half the diagram is shown, the other half being identical. The diagrams at the left and the right are from a rear and a front shock-absorber, respectively. In the latter the control varies from about 325 lb. at both the maximum-compression and maximum-rebound positions, to only 125 lb. for the boulevard ride. The characteristic of the rear shock-absorber is approximately the same as that of the front one, except that the adjustment is considerably lighter, only 50 lb. of control being used at the normal height, and the period during which the light control exists being longer.

Conclusions

The thought I have tried to present is that it should be possible to produce a two-way mechanical shock-absorber at a reasonable price that would give the desired degree of satisfaction, be adaptable to both light and heavy cars, and meet the demands of present-day driving. A great deal of development of shock-absorbers is under way today. Many other types of shock-absorber that have not been mentioned are in the course of development and some are actually on the market. We have tried, however, to deal with those which we consider truly representative, to give a general survey of the situation, and to stress emphatically the desirability of shock-absorbers of the two-way type.

Commercial Operation of Air Service

By C. C. Moseley[1]

Aeronautic Meeting Paper

AIRCRAFT operation in commerce is a question upon which the widest possible divergence of opinion exists. Except in a very general way perhaps no two operators are in agreement on any given point. They do not agree, in the main, as to what are the more important mechanical problems confronting them and, when they happen to agree on such a point, they find themselves in disagreement as to the solution.

Attention is directed to this condition within the industry because it has a very important bearing upon the statements made in this paper. The opinions expressed herein are those of our own organization as developed from observation and experience in the operation of the Los Angeles to Salt Lake City airway.

It should be borne in mind that a vast difference exists between the operation of aircraft as a weapon and the commercial application of this vehicle. This is a point which seems to have escaped many, although it should be obvious that a different practice is required in building, maintaining and using airplanes for military service as against practical commercial operation from which a profit must be earned. This does not imply any criticism of military or naval air services; it is intended merely to point a difference in the objectives aimed at and, consequently, the methods by which they may be attained.

Little criticism can be made of the mechanical practice worked out by our Air Services for the purpose intended, that of the development of aircraft as an arm of the National defense, entailing a certain amount of experimentation. But the same practices carried into the commercial field are too costly and therefore impractical. A good mechanical record can be made by commercial air-lines following the military practice, but the practices are too costly to permit of a profit.

The same relation holds as to types of airplane. In warfare, the demands to be made are vastly different from those that are required in commerce. For example, a military-airplane design aims at the greatest possible available high speed in emergency. Cruising speed is of secondary moment because, in fighting, it is necessary to go and return as quickly as possible. In commerce, the demand is for the highest consistent cruising-speed, the high speed taking secondary place, for here what is wanted is the greatest attainable steady gait.

Unfortunately, we have not yet really gone in for the designing of commercial types. The airplanes available for commerce are, in effect, worked-over military designs. The problem has been to adapt them profitably to the needs of commerce, to make them do a job for which they were not specifically designed and which, in at least some important details, has requirements directly contrary to the design. This, I believe, will explain the uneconomical operations of some of our air-transport companies. Virtually all American air-transport companies have made a gratifying record so far as reliability, dependability and regularity of service are concerned, but many of them have done this at prohibitive costs because of failure to appreciate in the beginning the economic problems with which they were confronted.

I can best illustrate my point by citing briefly the mechanical method behind the operations of the Western Air Express, Inc., which have been conducted at minimum cost.

At the inception of this venture 2 years ago, the question of airplanes was all-important. For the reasons outlined, we looked for a plane which combined the greatest cargo-carrying capacity with the highest speed at lowest cost in both initial investment and maintenance. This study naturally took powerplants into consideration, and our determination of all points swung finally to tried and proved types. We felt that experimenting is too costly to be carried on simultaneously with commercial operations with financial success. Our investment, therefore, took the form of purchases of the best available material for the purpose in view.

An adequate reserve of both airplanes and engines was established and the equipment, as individual units, have a power reserve that assures economy in practice. For instance, to maintain a 95-m.p.h. schedule, we secured a plane that on 75 per cent of its power has a cruising speed of 105 m.p.h. instead of, as was the case in some instances, taking a plane with a cruising speed lower than the schedule and therefore requiring the regular use of a considerable portion of its reserve power.

The result has been that maintenance costs have been extremely low. Both airplanes and engines have a

It should be obvious that a different practice is required in building, maintaining and using airplanes in military service as against practical commercial operation from which a profit must be earned. In commerce, the demand is for the highest consistent cruising speed.

We have not yet really gone in for the designing of commercial types. The airplanes availab'e for commerce are, in effect, worked-over military designs. This will explain the uneconomical operations of some of our air-transport companies.

Many improvements are yet to be made in airp'anes and engines before the airplane can render its full value to industry and commerce. Within another decade, shou'd the present rate of development continue, air transportation will be made as cheap as, or cheaper than, surface transportation for everything except bulk freight. This is the goal we should set for ourselves.

[1] Vice-president in charge of operations, Western Air Express, Inc., Los Angeles.

longer life than would otherwise be the case. There is a longer interval between overhauls and much less likelihood of mechanical accidents during flights. The vindication of this procedure is found in a performance record of nearly 700,000 miles of flying in 17 months, wth only four forced landings due to mechanical trouble and with only two delays in the dispatch of passengers or cargo.

In this operation we have built up a mechanical practice that is very satisfactory both in physical results and in the cutting of costs. Our planes are in the air one day in three. After each flight of 600 miles, each airplane goes into the hangar for two days. The first day it is inspected, checked and serviced; the second day it is in reserve; the third day it again takes the air on a scheduled run. This arrangement permits of the maximum care being given each airplane and minimizes the dangers of wear and tear.

Similarly with the engines. Each engine is run from 150 to 175 hr. between overhauls, depending upon the season of the year and the severity of service. Overhauls are made at intervals determined by our own practice as most compatible with safety and, consequently, greatest economy. The result has been most gratifying.

Many improvements are, of course, to be made in both airplanes and engines before the airplane can render its full potential value to industry and commerce. Planes designed exclusively for commercial use, engineered for economy of maintenance and operation, and combining heavy pay-load with the highest possible cruising speed, must replace the worked-over military designs now largely in use. A greater efficiency in powerplants also is desirable.

At present, the airplane in commerce cannot compete with surface transportation except where the element of time-saving has a value which permits of higher rates. To bring the airplane into full vigor as a medium of conveyance requires development to a point where it can compete in price with surface mediums. This eventuality is not improbable. Present costs are due largely to limited production and to defects which are rapidly being eliminated. Within another decade, should the present rate of development continue, air transportation will be made as cheap as or cheaper than surface transportation for everything except bulk freight. This is the goal which we should set for ourselves. Meanwhile, the necessity is to forget in commerce the methods of military establishments and to establish practices which combine consistent performance with economy. Only in this way, by cutting every corner, can costs be held down to a figure that will make operation profitable under the limited traffic of the present.

Production and Absorption

DURING the last 10 years we, as an industrial Nation, have been working production miracles almost daily. We have made record after record. We have witnessed more progress in mass production in these last 10 years than in all of the other thousands of years. We do not drop products out gingerly, one by one, any more. We pour them out in streams.

Having been thus ejected from the manufacturing machinery, these products must at once be got to some destination. There may be many intermediate destinations, but there is for all of these things just one ultimate destination, the well-known and justly celebrated Ultimate Consumer.

From 1899 to 1925 the industrial workers of the Country increased their daily production 49 per cent, according to the Census Bureau. From the beginning of the century to the present, agricultural workers increased their production 300 per cent, according to the same authority. The best figures obtainable seem to show that the real wage of industrial workers has increased but 5 per cent in that same period. In point of dollars, wages have fallen, in comparison with output, at a rapid and almost continuous rate for 20 years. That is, the value added by manufacture has increased much more rapidly than has the percentage of the total value of manufactures that is paid out in wages.

We have a practically constant unemployed total of 1,000,000, and we have 3,500,000 who are and have been during the last year employed only part of the time. We also have a great deal of machinery employed only part of the time. Thus we cannot even guess what our commodity total per year might be. All we can do is to draw some conclusions from what we do know about our actual output.

To put it as simply as possible: We have this growing stream of things. How shall they be marketed and where shall they be marketed? As that is answered, so goes prosperity. Our main market, the market upon which our wheels turn or stop, is at home, among the 111,000,000 inhabitants of the United States. We must have high buying-power and a growing degree of leisure. Statistics tell us that the man-hour increase in the production of automobile tires is 61 per cent. Now, the ability to buy automobile tires is not enough. There must be time for using automobile tires.

Time was when it was considered sufficient if a restricted class or group could absorb the products of the masses. That was when hand labor was the rule, extending down to comparatively recent periods when machine operations had only partially developed. But it will not do now. The whole mass must be the reservoir into which the stream of output flows. One rich family can use only a limited number of phonographs, eat only a limited amount of canned food, or of any food, use only so many clothes. All that the profligate can waste, even though he waste with all his energy, is so little in comparison with our vast machine-made totals that it counts for nothing in forming the market into which goods must be poured.

Those who will project themselves into tomorrow will understand that if this is so today it will be more emphatically and utterly inescapably so then. Tomorrow verges on today. The makers of machines, the inventors of processes, the chemists, and the engineers are at work, and they cannot stop. We are enmeshed in a wonderful progress which we cannot stop. The miracle is endless. The man who produces a given amount today will produce more tomorrow; and where will it go if it cannot go among those within the borders of our Country? How can it get there if there be not the power to buy?—Chester M. Wright, in *Printers' Ink.*

Continuation of the 1922 Report on Brake-Lining Tests

Discussion of S. von Ammon's Semi-Annual Meeting Paper[1]

A REPORT on the investigation of brake-lining materials by the Bureau of Standards was made by the author in 1922. The present paper gives information on work done in this field since that time. It places on record a summary and discussion of various test-methods and equipment at present employed by brake-lining manufacturers and others in the automotive industry. The difficulties connected with this work, resulting from the varying characteristics of brake-lining materials, are brought out. It is shown that some of the test methods in use do not furnish a basis for ready or fair comparison of different brake-linings. Other test procedures are so limited as to give only an incomplete picture of the characteristics of the brake-linings under conditions met in service; therefore, the test schedules generally require readjustment and amplification because a full and satisfactory knowledge of these materials can be obtained in this manner only. Finally, the essential features to be given consideration on the basis of present knowledge are reviewed and proposals are made which it is believed should, with reasonably limited tests, give a satisfactory picture of the character of brake-linings and a comparison of their relative merits.

The discussion of the paper consisted wholly of written contributions. Brake-maintenance information relative to noise and to the effect of grease on brake-linings, together with an outline of the causes of friction variation and the effect of water on brake-lining, the lubrication of brake linkage, and details relating thereto are included in the first portion. One discusser argues the desirability of using one type of testing machine. Another maintains that the temperature of the test is the keynote. A third maintains that the nature of the problem in hand influences laboratory tests of brake-lining. These and various other features are commented upon by the author.

Other features of the discussion include a statement of the advantages of the Carson type of machine, comments on the relative importance of the variation of the coefficient of friction, the advantage of intermittent tests, and the placement of emphasis on the desirability of agreement as to methods of testing brake-linings.

ALVIN M. YOCOM[2]:—The brake-maintenance information offered is based on contacts with the various car and brake service-stations which handle the brake maintenance of all types of passenger-car, motorcoach and truck, and on tests made personally. All the energy that can be put into a motor-car by a heavy engine within a given time can be dissipated in less than one-half of that time through a few ounces of brake-lining and, for this reason, the brake-lining seems to be one of the most highly stressed parts. Any change from the original brake-lining surface caused by the entrance of foreign material is likely to cause a wide variation in brake performance.

After brakes and brake-linings have been tested on instruments as explained by Mr. von Ammon, a number of factors are apparent that might cause the brake maintenance-troubles such as are reported from most brake service-stations. These factors cause what are commonly known as noise, lack of holding ability or glazing, and grabbing. A brake-lining drum-contact is a bearing. To keep the so-called bearing from being noisy, it is necessary to use the proper lining materials and saturant and to heat-treat the combination so that the saturant will not soften nor ooze at practical operating temperatures. For example, during recent brake-tests, a 4000-lb. car was coasted down a grade on the Mohawk Trail from an elevation of 2200 ft. With the clutch disengaged, the brakes were applied enough to maintain the car speed at 20 m.p.h. The total duration of the intermittent brake-application was 6 min. Immediately after the descent, the front-drum temperature was measured and found to be 265 deg. fahr., and the rear-drum temperature to be 295 deg. fahr. The brake-lining treatment or saturant showed no signs of softening. The rates of retardation, before and after the tests, were the same. A brake-lining treatment that would ooze at temperatures under 295 deg. fahr. is losing its original brake-lining qualities, which would

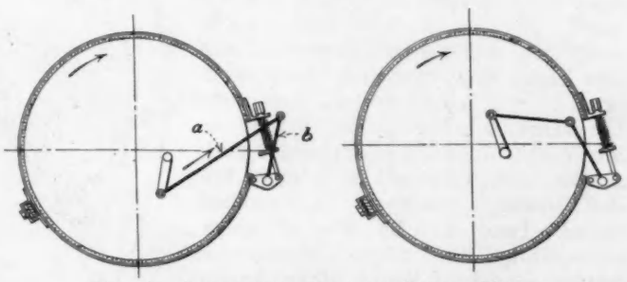


FIG. 1—CONDITIONS CAUSING BRAKE NOISE

Any Part of a Brake Mechanism That Prevents the Brake-Band or the Brake-Shoe From Taking a Normal Position in or on the Brake-Drum When the Brake Is Applied May Cause Noise. When Such a Condition Exists There Usually Is a Rapid Frequency of Taking-Hold and Letting-Go of Brakes That Sets Up Noises. The Brake Members Before and After Altering Their Position Are Shown in Solid Lines. Before the Alteration As Shown at the Left, It Was Impossible To Stop the Noise; but After Rearranging as Shown at the Right It Was Impossible To Produce Noise

[1] This paper was published in the November, 1927, issue of THE JOURNAL, beginning on p. 551. An abstract of the paper precedes the discussion. The author is a mechanical engineer for the Bureau of Standards, City of Washington.

[2] M.S.A.E.—Chief engineer, Multibestos Co., Detroit.

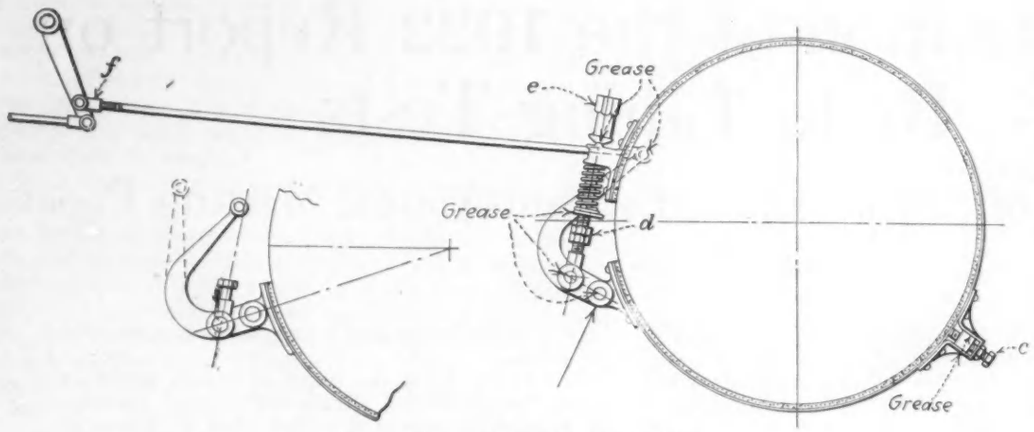


FIG. 2—QUIETING OF BRAKE NOISE

Some Brakes Produce Two Noises, Each Having a Different Source. One May Be High-Pitched and Shrill, and the Other a Low-Pitched Chatter. The Quieting of Each Kind of Noise Requires a Separate Remedy. The High-Pitched Noise Was Quieted by Oiling as Shown in the Upper View. The Low-Pitched Noise on the Same Brake Was Quieted by Releasing Adjustments on the Brake-Band at Points *c*, *d* and *e*, and Taking-Up on the Brake-Rod at *f* Until the Brake Parts Took a Position as Shown in the Lower View

give the lining contact with the drum a different surface; therefore, future brake-performance is apt to be noisy and erratic. The lining materials, saturant, and baking temperatures are important if lining noises are to be eliminated and uniform action is to be maintained.

Besides noise due to the brake-lining, brake noises have many other sources and the logical place to start to solve them seems to be at the point of contact of the lining with the drum. After being sure that the lining does not cause noise, the next step necessary in eliminating brake noises seems to be to lubricate all bearings around the brake-band. It will be agreed that parts of these brake bearings wear bright as brakes are applied. If the unlubricated bright spots are exposed to dampness for a few hours they rust and, when oscillated by the brake action, they have the same noise-producing ability as any rusty hinge. Drum contact with a rivet lacks lubrication, becomes hot and usually gives a high-pitched sound. Once in the life of every brake-lining the rivets should be driven deeper. Some other brake noise-producers are road grit and drum scorings that become embedded in the linings, and coats of drum-rust that pass from the drum to the linings often have noise-producing qualities. At the service stations it has been observed that brake performance can be improved greatly if coats of road grit, rust and steel scorings are removed from the lining surface with a wire brush, because this operation exposes the original surface of the lining.

Lubricating brake-band and brake-shoe linkage, redriving rivet-heads, eliminating road grit and steel scorings, and rustproofing the brake-drums are not cure-alls for brake noises. Any part of a brake mechanism that keeps the brake-band or the brake-shoe from taking a normal position in or on the drum when the brake is applied may cause brake noise. When such a condition exists there is usually a rapid frequency of taking-hold and letting-go of brakes that sets up noises. Fig. 1 shows an example. The brake members before and after altering their position are shown in solid lines. Before the alteration, as shown at the left, it was impossible to stop the noises; but after rearranging as shown at the right, it was impossible to produce noise. The ex-

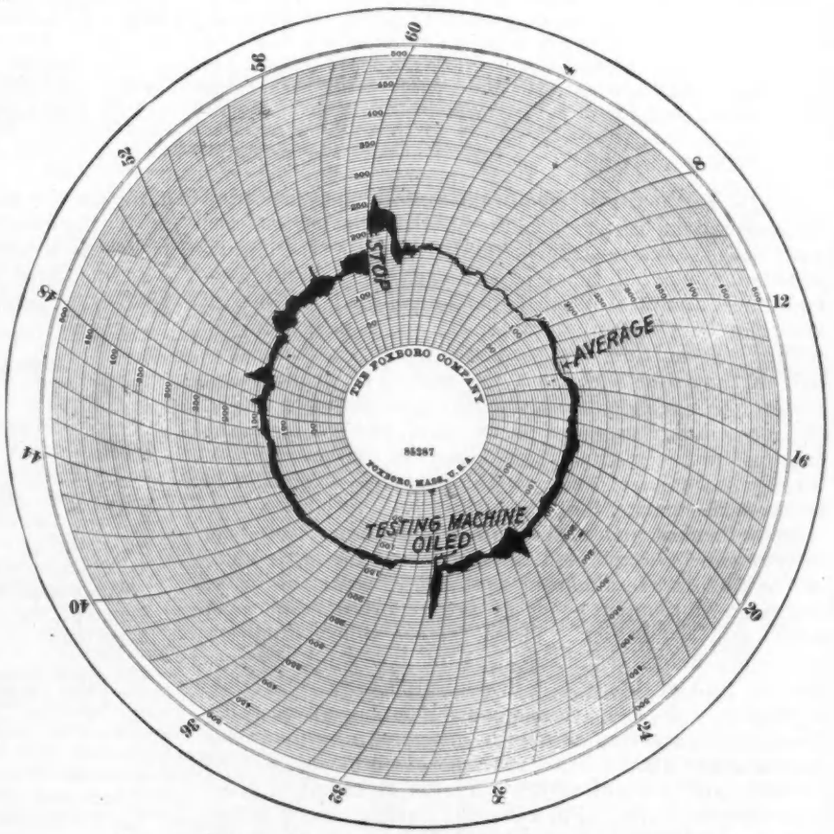


FIG. 3—MAINTENANCE OF THE COEFFICIENT OF FRICTION

It Is Possible To Make Brake-Linings That Will Maintain Their Friction Coefficient If Outside Elements Could Be Excluded. In the Illustration, the Friction Coefficient Was Maintained Above 0.3 During a 12-Hr. Contact with a 14-In. Drum Running at 320 R.P.M. The Sample of Brake-Lining Was 2 In. Square and $\frac{1}{8}$ In. Thick. The Coefficients of Friction at a Pressure of 30 Lb. per Sq. In. Were 0.537, the High Value; 0.303, the Low Value; and 0.350, the Average Value. The Average Wear per Hour Was 0.00166 In.

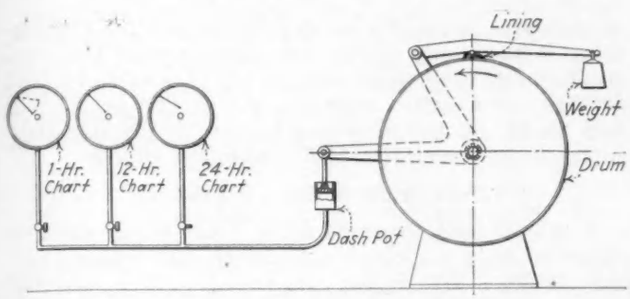


FIG. 4—DIAGRAM OF THE MACHINE ON WHICH THE CHARTS OF FIGS. 3 AND 5 WERE OBTAINED

planation of this seems to be that the direction of the force in rod *a* kept the brake-band anchor-cleat from coming properly against the anchor-pin and pushed the band from its normal position on the drum. Besides this, the connection to lever *b* was on the wrong side of the considered center of moments of the lever and pushed the parts farther from their normal position, causing a rapid taking-hold and letting-go of the brakes, and noise resulted.

Some brakes have two noises, each having a different source. One may be high-pitched and shrill, and the other a low-pitched chatter. The quieting of each noise requires a separate remedy. Fig. 2 helps to illustrate a recent case; the high-pitched noise was immediately cured by oiling as shown in the upper view. This sound apparently was caused by the oscillation of a rusty hinge. The low-pitched noise on the same brake was quieted by releasing adjustments on the brake-bands at points *c*, *d* and *e*, and taking-up on the brake-rod at *f* until the brake parts took a position as shown in the lower view. This can be explained as follows: From investigation of many brake noises it seems that the ends of brake-bands should travel in a path which is tangent to the drum surface at the contacting point or the band ends will cause noise such as a chair causes when it is pushed back by a person rising from it.

EFFECT OF GREASE ON BRAKE-LININGS

Due to the difficulty experienced in sealing bearings against grease leakage, the question often is asked, "What is the effect of grease on the coefficient of friction of brake-linings?" Investigation of many brake-linings shows that grease will vary the friction coefficient from 0.15 to about 0.50, or about 350 per cent. When the grease on a lining is more or less cold and pasty, the friction is high and the first few brake applications are apt to be too harsh. As the grease warms in making traffic stops, the friction and the retarding ability drop rapidly as the grease thins and forms a lubricating film between the lining and the drum. The brake service-men, in many cases, call this "lining glaze," as the presence of half-dry grease that is causing the trouble is often difficult to detect. Close study of the problems in hundreds of cases discloses that lack of holding ability or so-called lining glaze is caused by wheel-bearing grease-leakage or grease that is thrown from the front pinion-bearing to the brake-drums until the linings become saturated.

OTHER CAUSES OF FRICTION VARIATION

With consistent brake-performance in mind, other factors in addition to grease are apt to cause friction variations. Fifty coats of rust that pass from the drums and embed in the linings, or an equal amount of road grit, will change the original nature of the lining surface and vary the friction of a lining from 30 to 40 per cent. Contacting rivet-heads or drum scorings have about the same effect. For instance, if rivet heads start scoring the drum, friction is increased; if they do not score but only contact, the friction is reduced and linings are said to glaze. There is such a condition as lining glaze and it has been explained as carbonization or charring of the lining saturant due either to brake heat or oven heat during the lining treatment. On the other hand, it is possible to make linings that will maintain their friction coefficient if outside elements can be excluded. Fig. 3 shows the friction coefficient maintained above 0.3 during a 12-hr. contact with a 14-in. drum running at 320 r.p.m. The pressure on the lining during this test was 30 lb. per sq. in. Fig. 4 shows the machine on which the charts in Figs. 3 and 5 were made. Once the lining is placed in the machine and the motor started, the functioning

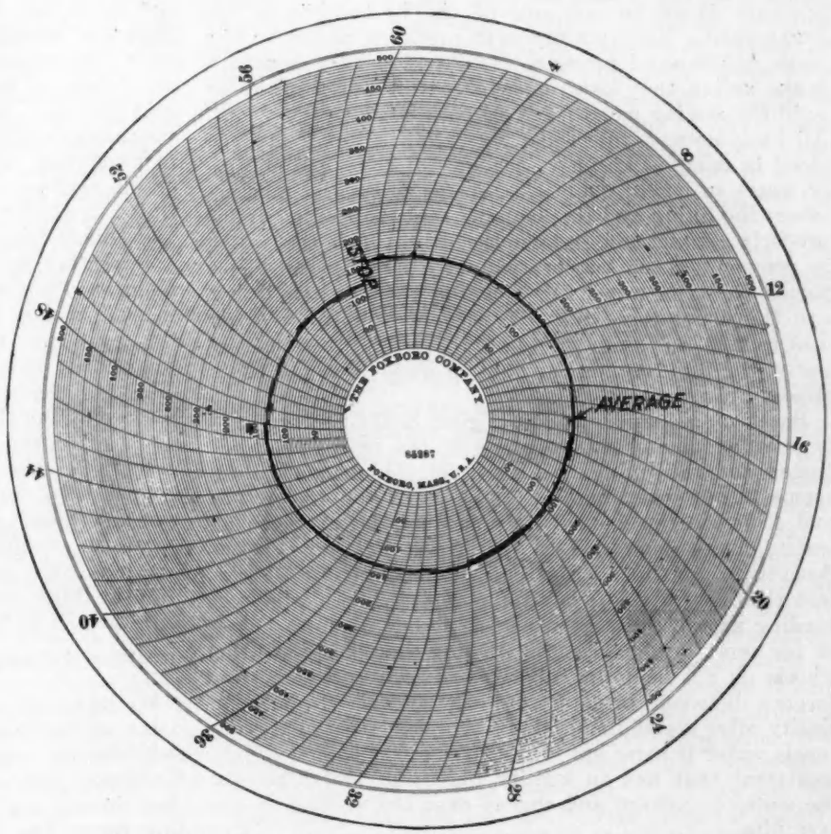


FIG. 5—FRICTION CHART OF A NEW PIECE OF BRAKE-LINING

The Sample Was 2 In. Square and $\frac{1}{16}$ In. Thick and Was Applied to a 14-In. Drum. The Coefficients of Friction at 320 R.P.M. and a Pressure of 30 Lb. per Sq. In. Were 0.400, the High Value; 0.306, the Low Value; and 0.344, the Average Value. The Average Wear per Hour Was 0.002 In.

and registering are entirely automatic and the result is, therefore, free from errors often introduced when it is necessary to make observations and tabulations continuously. Fig. 5 shows the friction chart of a new piece of lining as it is cut from a roll of lining which is ready for shipment.

Effect of Water on Brake-Lining

Other foreign elements raise the brake efficiency to a point which seems nearly ideal. For example, at times just enough moisture gets between the lining and the drum to give them a sucking fit. This excludes the air from between drum and lining and the atmospheric

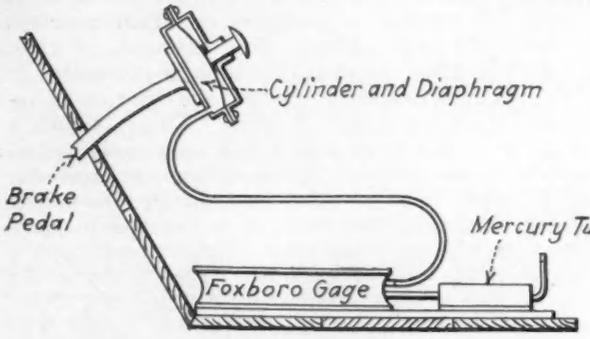


Fig. 6—Device Designed to Check the Road Performance of Brakes and Brake-Linings After Improvements Are Made

pressure is all on one side of the brake-shoe or the brake-band. This atmospheric pressure added to the usual brake-pedal pressure results in a very sensitive brake action that lasts only for a few applications or until the sealing moisture is evaporated or squeezed out. All have noticed this sensitive action after a car has stood in damp atmosphere for several hours. Moisture, or water in larger quantities, seems to form a film between the lining and the drum so that the lining cannot properly contact and retard the drum until the water is pressed out or evaporated out. During the short period that the water film remains between the lining and the drum the friction coefficient will range from 0.15 to 0.25, and it seems to vary with the thickness of the water film and the amount of road dust which is almost always present.

Based on a number of tests, good brake-performance is possible during wet weather if the brakes are adjusted so that linings are close to the drums. This seems to cut down on the thickness of the water film and to house the drum better against the entrance of water. Brake performance during wet weather is often deceptive. At times it has been noticed during a brake test that the wheels are sliding but the decelerometer reading shows a loss of stopping ability of as much as 40 per cent. The brakes are holding the wheels but the wheels do not hold the car. There seems to be a difference between brake-linings as related to holding ability after water immersion. A lining treatment that repels water is more apt to perform better than a lining treatment that has an affinity for water which causes the water to adhere and spread over the surface in an even film.

To check the road performance of brakes and linings as improvements are made, a device has been designed as shown in Fig. 6. This mechanism registers on a chart the number of brake applications, the duration of each application, the pedal pressure and the retardation. With the use of this instrument a more thorough study of results is made possible and it is expected that further investigation with the aid of this device will help in giving better cooperation with the manufacturers in the development of brakes and linings.

Lubrication of Brake Linkage

A case of what is often called brake-lining glaze is instanced by a car which was driven into a brake service-station. The brakes of the car were adjusted within specified limits. Several test-stops were made and the deceleration was noted not to be up to standard. Next, all the bearings in the brake mechanism were lubricated, starting at the brake-pedal bearing and including the brake-band linkage. When the next deceleration readings were taken, it was surprising to find that the holding ability for the same pedal pressure had increased 30 per cent.

Even though brake performance has been improved 100 to 200 per cent in many cases within the last 5 years, if a means can be found to keep the brake linkage lubricated, performance can be improved still further and much erratic brake-performance too often blamed on brake-lining can be eliminated. Since the modern light-weight brake-mechanism is capable of doing several times as much work as a sturdy engine, is it not logical to believe that such a heavily loaded device should be lubricated if it is consistently to do what is expected of it?

S. von Ammon:—The service to which brake-linings are subjected, even under favorable conditions, is such that they should not also be expected to compensate for such factors as poor brake-design, improper adjustment, lack of maintenance, shoddy methods of riveting and the like. Unfortunately, this is not sufficiently appreciated in many quarters. Mr. Yocom's presentation of numerous factors met in brake operation and which create unfavorable operating conditions for the brake-lining is therefore a valuable supplement to my paper and should help to a better understanding.

Referring to the brake test of a heavy car on the Mohawk Trail which Mr. Yocom mentions, and assuming an average grade of about 6 per cent, it seems that the total time during which the brakes were applied constituted from one-quarter to one-third of the time taken to descend the trail. The cooling during the balance of the time would have been good, owing to the speed maintained. As the drum temperature as measured "after the descent" is given, the maximum drum-temperature during the descent may possibly have varied considerably from the values measured. Temperatures considerably higher than the values given do occur and the nearer brake-linings come to withstanding the high temperatures that may occur the more satisfactory will the linings be.

Claims Based on Limited Data

We have not been able to test all of the newer linings using saturants and heat-treatments to make them more suitable for operation at the higher temperatures. However, those tested so far have shown a material drop in the coefficient at some temperature range and this range has been well below the limit up to which these linings were said not to be affected.

Possibly, as Mr. Yocom states, "it is necessary to heat-treat the combination of lining materials and saturant so that the saturant will not soften nor ooze

out at practical brake-operating temperatures," but although this may be possible with the saturants in use at present and without introducing other features considered objectionable, so far as our tests go, linings so treated have not come to our notice. Nor does the test result shown by Mr. Yocom in his Fig. 3 or the even smoother curve of his Fig. 5 prove his statement that "it is possible to make linings that will maintain their friction coefficient if outside elements could be excluded," as they presumably were in these tests. From the data shown in his Fig. 5, the power absorption varied from 1.27 to 1.7 hp. The temperature under these conditions was probably between 130 and 150 deg. cent., say 260 and 300 deg. fahr. At a temperature even slightly different, the coefficient of friction might readily have fallen much below 0.30 or shown an erratic behavior. Reference to Fig. 16 of my paper will show that while the 1-hr. test with a pressure of 30 lb. per sq. in. showed but small variations in the coefficient of friction, the test at a pressure of 50 lb. per sq. in. gave an entirely different picture and shows the effect of the higher temperature on the coefficient of friction. To repeat, we should not allow ourselves to be misled by the results obtained under a limited set of conditions unless some set can be found which will give a reasonable picture of all the possibilities.

Desirability of One Type of Testing Machine

C. Bockius[3]:—I think that Mr. von Ammon has made an extensive exposition of the various types of equipment employed. All the data clearly indicate that one type of testing machine should be definitely decided upon and rigidly adhered to. I cannot help but feel that for every engineer to express his individual ideas in the design of a testing machine only leads to a chaotic condition in test results and in the conclusions to be drawn from the data which are obtained by using these various machines. We have endeavored several times to develop a special machine for testing brake-lining, but all our efforts have confirmed our conclusion that the particular type employed by the Bureau of Standards is more desirable for the average engineering laboratory. I am thoroughly convinced that the method of operation of the present Bureau of Standards testing machine, such as speed, pressure, absorbed load and the like, are not analogous to road conditions; but this equipment can yield data which, when studied intelligently, can give valuable information. I grant that this information may not be strictly in accord with data obtained with road tests conducted on cars having various designs of brakes, but, in general, the data obtained help to advance the art.

It is questioned whether a laboratory test can ever approximate tests of brake-lining conducted upon the road with various designs of brakes; but it is my belief that tests of brake-lining in the laboratory yield valuable data, and the laboratory results should be interpreted in a similar manner to the block tests of automobile engines, which yield valuable information regarding the performance of an engine in the laboratory but are used as only part of the series of tests necessary to evaluate a particular design, and, with the other tests, include a critical check of performance in road work. If we use the data obtained in laboratory testing of brake-lining to assist us in the interpretation of road-test results with various brake designs, we cannot reasonably expect anything further.

Mr. von Ammon:—I understand that Mr. Bockius has carried on very thorough and systematic laboratory tests, chiefly under the original conditions of the severe-service test of the Bureau of Standards and supplemented by road tests. This work has no doubt yielded much information on the influence which the various materials and treatments used have on the ultimate behavior of the finished brake-linings. His comments indicate that the information obtained, even under the very limited conditions of the severe-service test, has been found valuable. This is no doubt largely due to Mr. Bockius' skill in analyzing the results and correlating them with the information gained from the road tests. The more nearly the laboratory tests cover the whole range of capability of the brake-linings, the easier will be the correct interpretation of the results of both laboratory and road tests. As stated, the Bureau of Standards is occupied with the further development of the laboratory tests. Meanwhile it has been the endeavor to design the test equipment so that it would prove suitable for a wide choice of test conditions.

Temperature of Test Is Keynote

George B. Allen[4]:—I think Mr. von Ammon is familiar with the amount of testing and style of test we have been conducting in the last 2 years. Our method of test naturally is not so complete as that of the Bureau of Standards, but we believe that the results of our tests have given us valuable information regarding the characteristics of brake-lining at fairly high temperatures; in fact, duplicate tests of the same lining have given us very close results. It seems that our check of materials has been as accurate in results as have the tests by the Bureau of Standards, which have been made with great care. If some means could be determined by which the temperature of the brake-lining would be controlled more accurately, I believe our results would then check still more closely. It seems that the temperature at which the tests are made is the keynote of the whole situation.

Mr. von Ammon:—It is evident that Mr. Allen's experience confirms our finding as to the predominant influence of the temperature and the importance of making comparative tests on the basis of controlled temperature. Control of the temperature in tests offers no difficulty provided the power absorption during the tests is kept constant and the tests are not made with constant brake-shoe pressure. As all the power is converted into heat, the temperature rise above room temperature is determined on the one hand by the power absorption and on the other hand by the rate at which this heat is dissipated. A given test-equipment having identical test-conditions and a given power-absorption which is kept constant will result in the same amount of heat generated, the same heat-dissipation and the same temperature-rise. Variable room-temperatures will cause differences in the absolute temperature, but the influence of these differences should not be troublesome, as it is smaller than that of even minimum unavoidable differences between samples of the same brake-lining. Variations in the equilibrium temperature during a given test, as shown by thermocouples carefully placed and handled, may result from variations in the pressure distribution over the face of the brake-lining and consequent changes in the local power-absorption. An increase in pressure occurring tempo-

[3] M.S.A.E.—Development manager, Manhattan Rubber Mfg. Co., Passaic, N. J.

[4] M.S.A.E.—Research engineer, Dodge Bros., Inc., Detroit.

rarily near the locus of the thermocouple will, of course, result in a higher temperature being indicated.

From the foregoing comment it will be clear that if, for a given machine, the equilibrium temperatures for a given size of test-specimen and speed are determined carefully for a number of power absorptions, we can use the data for determining the power absorption necessary for any given equilibrium temperatures at which we find it advisable to test brake-linings to secure a reasonably full knowledge of their behavior.

Problem in Hand Influences Laboratory Tests

CARL F. OGREN[5]:—The paper is a most complete summary of the methods used in the testing of brake-linings. For the last several years there has been considerable argument relative to the value of various forms of brake-lining test. Although much has been done, it seems to me that we are still far from the point where we can say that one test is right and some other test is wrong. Laboratory conditions have not come sufficiently close to road conditions; therefore, I believe that the laboratory tests must take into account the particular problem at hand. It is a well-known fact that one lining will not work so well as another lining on a particular brake. One brake-design will require considerable wrapping action, while another will work better with less wrapping action. A softer lining will give greater wrapping action than a harder lining. Then, also, the coefficient of friction which is suitable for one brake will not be suitable for another. None of these variations is accounted for in laboratory tests. The tests would assume a constant set of conditions.

In making both hot and cold tests on the same kinds of brake lining over a period of several years, it has been my experience that the cold test will give a more uniform coefficient of friction under the test and that we can obtain better checks on wear under a cold type of test. In this cooler test the compound or the saturant, depending on its type, is not heated to the destruction point and consequently approaches more nearly the actual service-conditions.

MR. VON AMMON:—In reply to Mr. Ogren, I want to repeat what I have tried to emphasize in my paper, that the test or series of tests is most nearly right which gives us the most complete knowledge of the characteristics of brake-linings over the whole range of their "capability." Brake tests on the road, perhaps supplemented by brake tests in the laboratory, will serve to ascertain the operation of various brake systems and to show the brake-lining characteristics necessary for the best operation of a given brake. With the knowledge gained from these brake-lining and brake tests, the lining best suited for a given brake can be selected from those available. A thorough knowledge of the brake-linings will also point the way to the development of linings so modified as to meet special brake-requirements still better.

Dependence on brake or road tests alone is apt to be misleading on account of the difficulty of assessing accurately the influence of the various factors introduced through the inclusion of the brake mechanism. There is no objection whatever to the adoption of a constant set of conditions for the laboratory brake-lining tests, so long as such conditions cover the necessary range to give the knowledge desired.

In comparing the results of hot and cold tests, Mr. Ogren says that the cold test, by which he refers I think to the test with a water-cooled drum, gives a more uniform coefficient of friction. This confirms our experience. However, if a full knowledge of the brake-linings rather than just a good laboratory showing of the lining is desired, this finding is a good reason for adding such test conditions as will show the behavior of the lining under conditions less favorable to the maintenance of a uniform coefficient of friction. As mentioned in my paper, the largest drop in the coefficient of friction occurs under conditions intermediate between those of the water-cooled-drum tests and the very severe destructive-temperature tests. As the temperature is the main factor influencing the coefficient of friction, it seems relatively simple to obtain a good knowledge of a given brake-lining in this respect. Just what test conditions will yield the most reliable information on the relative durability of different brake-linings under average road-conditions will require considerably more work.

Durability of Similar Samples

C. E. HARWOOD[6]:—The paper is most comprehensive. The numerous illustrations add greatly to the understanding of the text. The author states that the differences occasionally found in the durability of several pieces of the same brake-lining result from the lining. I want to take issue on this point. Our Lockheed type of machine is built as a double-header; that is, with a drum on each end of the shaft. The speed is 225 r.p.m. and the period of application is 5 sec. at 2.5-min. intervals. Running the two sides with lining cut from the same strip, a torque difference of more than 100 lb-ft. was found. Although the lining itself will vary, it cannot be made more uniform than adjacent pieces on the small roll.

Checking the mechanical end, we have made corrections which reduced the error to 8 lb-ft. I have found similar trouble in service, and the fault is always laid to the brake-lining; but I believe that assuming a 50-50 basis as between lining and other causes still leaves room for doubt.

In regard to the predominant influence of the tem perature on the coefficient of friction, as referred to in the paper, my experience in service checks with this and we are spending much time and money to determine the cause and the cure. In general, my chief criticism of the paper is that the author does not bring out strongly enough his objections to the various types. No doubt it is necessary to use tact, but objections will give us users food for thought and direct evidence to counteract.

MR. VON AMMON:—The variations in durability to which I referred as occasionally occurring were mentioned in connection with the severe-service test. We have in a few cases found that one piece of brake-lining would wear say twice as fast as another piece from the same roll. In these extreme cases the cause lay in the formation of a hard abrasive deposit on the drum which would cause the more rapid wear of that sample of lining. Checking the analysis of the drums and the behavior of the same drums with other linings, and remembering that the power absorption is kept constant with the Bureau of Standards machines, the evidence seems to indicate clearly that the differences in durability resulted, as stated, "not from the test equipment or conditions but from the lining material itself or

[5] M.S.A.E.—Chief of physical and chemical research laboratories, Thermoid Rubber Co., Trenton, N. J.

[6] Russell Mfg. Co., Middletown, Conn.

variations in the same, though possibly interaction between lining and drum material may also have some effect."

A Difficulty with a "Brake-Testing" Machine

Mr. Harwood states that, by a check of the mechanical end of his machine, the difference shown in the torque of the two ends of the machine was reduced from 100 lb-ft. to 8 lb-ft. It is not clear from this whether the adjustment was made on the assumption that the two brakes lined with material from the same roll should, if properly adjusted, show the same torque. Even the difference of 8 lb-ft. is apparently regarded as an "error." Differences in the two separate though similar brake mechanisms and their adjustment might cause considerable differences in the brake-lining pressure with the same pedal pressure or hydraulic pressure in the supply line. Differences of 8 lb-ft. or perhaps much more in the braking torque might have to be accepted rather than being classed as errors. In view of this, it seems difficult to ascertain when one or more such brake-testing machines are correctly adjusted or to obtain from them accurate data on the coefficient of friction.

I regret that Mr. Harwood feels that I have not brought out the objections to the various types of test equipment strongly enough. I endeavored to comment on the various equipment in such a manner as to illuminate the important features to be observed to secure a better knowledge of the materials under discussion, without excluding from my paper "food for thought." Mr. Harwood's reference to his own difficulties adds information of value and points particularly to the need for eliminating such factors as brake design in tests intended for the determination of the characteristics of brake-linings, rather than brake mechanism.

Types of Asbestos Brake-Lining

J. M. Weaver[1]:—This contribution to the discussion of Mr. von Ammon's constructive paper on brake-lining tests is made from the standpoint of a brake-lining manufacturer and is based upon conclusions drawn from observations made during an experience of a quarter-century in the manufacture of the product.

There are two general types of asbestos brake-lining. One is a fabric woven to the thickness desired and finished with a saturant or treating compound, and the other is made by applying a rubber compound upon asbestos metallic-cloth and folded to build up the size and width required. The first type has been used as the base for the application of many kinds of treating compounds, running through the various kinds of asphalts and combinations of them, and various other chemical compounds. In both types of brake-lining, the fabric is composed of asbestos metallic-yarn. The yarn is a mixture of asbestos and cotton in the approximate proportions of 80 per cent asbestos and 20 per cent cotton. Ordinarily, the wire used is brass or copper, and the asbestos is spun around the wire. The brake-lining manufacturer therefore works with four principal ingredients: asbestos fiber, cotton fiber, brass or copper wire, and treating compound.

Asbestos is a mineral, belonging to the hornblende family, to which talc also belongs, and it is not uncommon to find asbestos fiber displaying marked lubricating qualities due to the talc content. It follows that the frictional quality of asbestos fiber is not the outstanding characteristic that makes it valuable for brake-lining.

The frictional quality of any material depends, in my opinion, upon two characteristic qualities; namely, hardness and toughness. Those materials which are easily indented and, at the same time, offer the greatest resistance to abrasion, show high coefficients of friction. For example, natural cork has a high coefficient of friction because it is easily indented and therefore will intermesh fully with the microscopic irregularities of anything with which it comes into contact under pressure, and its toughness resists abrasive action. Asbestos is exceedingly smooth fiber of stone, which, when twisted into yarn, offers a cushion-like character that results in the production of a considerable frictional quality, but that quality is enhanced by the inclusion of a percentage of cotton fiber, which is strong and at the same time soft, and gives to the yarn a higher value in its ability to engage with and to resist the tear of the microscopic projections on a steel brake-drum.

Long experience has demonstrated that the brake-lining manufacturer can build into his product a high coefficient of friction or a high wear-factor, but that it is impossible to build into the same brake-lining the utmost of each of these qualities. A high coefficient of friction is obtained as the result of abrasion or wearing away of the fabric. Avoidance of the abrasive action results in a lower coefficient of friction. Mr. von Ammon says:

> Asbestos, as the result of its heat-resisting qualities, forms the basis of most present linings; but, for well-known reasons, it is combined with other materials of less heat-resistance. As the combination is also less heat-resistant, it does not permit of the qualities of the asbestos being utilized to their full extent. Tests show that some of these other materials at least largely contribute to, if they do not entirely cause, the lowering of the coefficient of friction. The materials added do not reduce the magnitude of changes in the coefficient of friction but rather increase it.

Treating Compound May Reduce Frictional Value

The foregoing quotation indicates that a brake-lining made of asbestos alone would have a higher coefficient of friction than is obtained from the product as it is now produced. As I already have pointed out, the cotton content should increase the frictional quality, and the wire should not noticeably decrease it, being softer than the material of the drum. The treating compound is the ingredient that may cause a reduction in frictional value. Treating compounds have been developed that do not react under the heat of friction as indicated by Mr. von Ammon. Improvements have been made that eliminate the extensive "bleeding" of the saturant to a condition that makes the treatment act as a lubricant upon the surface of the brake-lining. I think it well to point out the fact that a treating compound, or saturant, in brake-lining is the one ingredient that most largely effects changes in coefficient of friction, due to the fact that it is the one ingredient most affected by the frictional heat developed in braking service. Mr. von Ammon concludes that:

> While for other reasons the omission of the saturant in present linings is not feasible, these data indicate that the asbestos is placed at a disadvantage by the other constituents.

I must register a negative opinion regarding the

[1] General sales manager, Keasbey & Mattison Co., Ambler, Pa., and president of the Asbestos Brake Lining Association.

foregoing statement. It has been shown conclusively in the manufacture of more than 300 styles of brake-lining in the laboratory of the company with which I am connected that the "other constituents," that is, cotton and brass wire, contribute materially in the construction of a lining that will have a satisfactorily high coefficient of friction and at the same time be wear-resistant. In other words, the asbestos content is not placed at a disadvantage by these constituents. There is sufficient asbestos in a mix containing 80 per cent to protect the fibers of cotton from the destructive action of frictional heat, and the cotton adds strength to the yarn, as does also the brass wire. The cotton and brass make it possible to twist a yarn tighter, thereby providing a yarn surface, when tightly woven, that resists the abrasive action of the microscopic projections on the face of the steel drum.

Influence of Brake-Drum Material

Mr. von Ammon acknowledges that the results of the tests made at the Bureau of Standards have been recorded without regard to the material composing the drum; in other words, that the carbon content of the steel has not been regarded as a factor in determining the rate of wear and the coefficient of friction. Both the coefficient of friction and the wear-factors have been recorded as attributable solely to qualities lying within the brake-lining itself. In fact, there are two surfaces in contact, each of which is contributing to the friction developed and also to the amount of abrasion or wear-factor developed. The two surfaces offer microscopic irregularities that intermesh, and each surface is abraded by the rubbing away of the microscopic projections. It is the resistance set up by these microscopic projections that produces the friction.

The nature of the steel surface will be found to vary considerably with the carbon content of the steel. It is well to bear in mind that the coefficient of friction set for the brake-lining on a particular drum is also the coefficient of friction developed for that drum surface in that particular test. A steel drum having a low carbon-content is soft when compared with a steel drum having a high carbon-content. The harder steel will take a higher polish and present, perhaps, fewer microscopic projections to arrest the movement of the brake-lining over the surface of the steel. It follows that with a high-carbon steel an increase in pressure would be necessary to develop the same frictional qualities that would be obtained with a lower pressure upon a softer steel. It also follows that a hard and dense brake-lining requires more pressure to develop the same braking effect than is required with a softer lining. A soft lining, having the toughness to resist the action of the microscopic projections on the surface of the drum, will show a high coefficient of friction. A dense lining and one that takes a high polish will have a longer life, due to the fact that there is less abrasion or cutting away of the surface, with a resulting lower friction quality and consequently a lower coefficient of friction.

The design of braking mechanism and the material decided upon for the drum are factors that are equally responsible with brake-lining in the production of the safety factor in a motor-vehicle. The trend of automotive engineering has been to produce speed. It is equally important to include in the design the materials for drums and mechanism that will effect the stoppage of the vehicle at high speeds within reasonable distance upon all kinds of road surface.

The nature of the road surface is a factor that has a great bearing upon the question of deceleration. After all, it is the friction between the tire and the road that stops the car, whereas the brake-lining overcomes the kinetic energy of the vehicle by retarding the rotation of the wheels. The design of the brake should provide a sufficient number of square inches of braking surface between the lining and the drum to place upon each square inch of braking surface a burden of absorbing only a certain amount of kinetic energy or foot-pounds of force. Working out this problem, the nature of the steel in the drum, the diameter of the drum and the width of the face, as well as the leverages provided for the braking mechanism, should be given due consideration, for all these are factors that have a bearing upon the way in which brake-lining will perform.

The brake-lining manufacturer is offering today a product made of carefully selected asbestos fiber mixed with the minimum quantity of cotton that is commercially practicable, with an inclusion of only the percentage of brass wire that adds to the strength of the fabric, and a treating compound or saturant that should add to the frictional qualities of the lining under all temperatures generated in braking service. The manufacturer holds the opinion that the first essential of brake-lining is to stop the vehicle, and that the wear-factor is of secondary importance. The principal purpose of the tests made by the Bureau of Standards for the Governmental purchases of brake-lining was to establish a low wear-factor. Manufacturers have met that demand by offering linings constructed to show a low wear-factor, but at the same time have held in view the necessity of retaining a satisfactory coefficient of friction in the product.

Trend Toward Better Brake-Lining

C. A. Baer[8]:—The paper is a valuable contribution to the brake-lining industry. The results of tests, as brought out, particularly with regard to improvements in the durability factor, are rather conclusive. Our attention is called to one of the author's conclusions, as follows:

> In view of the lining manufacturer's present difficulties, it is perhaps fortunate for him that after a fatal accident the coroner, while casting one eye on the car owner, does not yet turn the other on the creator of the lining material.

While it is true that some manufacturers have, in their advertising, been prone to make claims for their linings which cannot be substantiated, we believe that the general trend has been to the manufacture of better and better grades. The best brake-lining, improperly applied or applied on improperly designed brake-rigging, may fail when put to a severe test. Whether this be the result of bad designing or neglect on the part of the motor-car builder or on the part of the owner should be the primary question for the coroner to decide before casting blame on the brake-lining manufacturer.

The best asbestos brake-lining is manufactured of chrysotile asbestos of long fiber mixed with long-fiber cotton, preferably Sea Island cotton, with only sufficient cotton employed to facilitate the manufacturing processes and to hold the saturant. These asbestos strands are twisted with heat-resisting wire to assure strength

[8] Mechanical engineer, Keasbey & Mattison Co., Ambler, Pa.

at all temperatures. Woven brake-lining should be uniform in composition, dense in weave, have a fairly high coefficient of friction, and minimum variation when subjected to the higher temperatures found under usual operating conditions. Cheapening the lining by reducing the quality of asbestos results in a greater proportion of cotton and a decidedly inferior product.

More Improvement of Brake Design Needed

The trend today has been for the motor-car builders to devote their time toward higher-speed engines and body and chassis improvements, with little real endeavor to improve the design of the brake mechanism or lining. With the denser traffic and higher speeds, attention must be given to the "safety-first" feature of better and dependable braking. In the past it has been apparent that the majority of brake-drums were of poor design, lacking in rigidity and subject to distortion from high temperatures. Little or no thought has been given to the amount of carbon in the metal. Brake-linings have been applied with rivets of inferior alloy which crystallized upon being subjected to operating temperatures, allowing the lining to be snapped off when under strain. The recent development of the four-wheel brake has given publicity to this part of the car, but there is still an opportunity for great improvement in brake-lining and in the materials and the design of the brake-rigging.

Mr. von Ammon states that "the greater wear at the lower speed for any given horsepower is due chiefly to the decreased cooling at this speed." For any given horsepower, reducing the speed one-half necessitates twice the amount of pressure, which forces the brake-lining material into the minute depressions of the brake-drum to a greater extent and results in noticeably greater wear. The author states also that: "It would, however, seem reasonable to test linings offered or considered for general service-conditions on the drum material least favorable to the durability of the linings." Such a procedure naturally would be in the wrong direction and unfair to the brake-lining. It is far better to educate the motor-car builders toward using the most favorable metal for the brake-lining they wish to adopt.

Analysis of Braking Conditions

I shall analyze the conditions which actually occur during the braking operation, as these are at variance with those met in the laboratory. Consider a Packard car weighing 4710 lb. which has a total area of lining on service brakes amounting to 333 sq. in. It is recommended that such a car, equipped with four-wheel brakes, traveling at 30 m.p.h., should stop in about 55.5 ft. On the assumption that *constant deceleration* is employed, if this car stops in 55.5 ft. it should do this in 2.5 sec. If the entire work of retarding the car were taken care of by the brake-lining, with an assumed average coefficient of friction of 0.4 for the lining and with a ratio of wheel diameter to drum diameter of 2.35, the pressure applied normally to the brake-lining to produce this braking effort would amount to 45 lb. per sq. in., representing a drum pressure of 7½ tons for the total brake-lining service.

In fact, the brake-lining is not responsible for the entire retarding of the car. It is assisted by the resistance to rolling friction, the cylinder compression, the engine friction, and wind resistance. The wind resistance is proportional to the square of the velocity. The resistance to rolling of rubber-tired vehicles is practically constant, depending little upon the speed but almost entirely upon the car weight. The engine compression and transmission friction depend upon the actual design of the car.

On the assumption that the deceleration is constant, Fig. 7 is presented to illustrate to some extent the braking action of the rear wheels and front wheels.

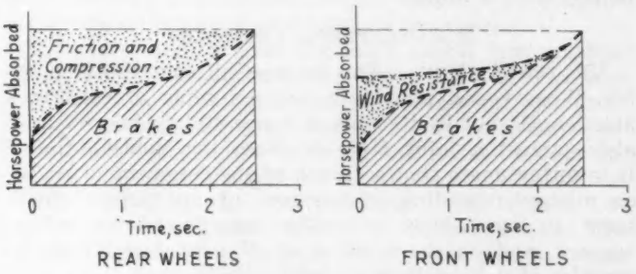


FIG. 7—REAR-WHEEL AND FRONT-WHEEL BRAKING-ACTION COMPARED

The Charts Assume Approximately Constant Deceleration, the Cross-Hatched Portion at the Left Showing the Power Absorption Throughout the 2.5-Sec. Interval of the Rear-Wheel Brakes, the Stippled Portion Representing the Resistance to Rolling Friction and Retarding Effort of the Engine and Transmission Transmitted Through the Beveled Gears Directly to the Rear Wheel. The Rear-Wheel and Front-Wheel Brakes Are Adjusted Equally, and the Cross-Hatched Areas Are the Same. The Stippled Portion at the Right Shows the Wind Resistance Which Is Applied Directly Against the Car as a Whole

The kinetic energy of this car at 30 m.p.h. is 141,900 ft-lb. and, when brought to a stop by constant deceleration in 2.5 sec., the power-absorption in this braking effort is 103 hp. As approximately 0.6 of the weight of the car rests upon the rear wheels, the limit of the car's retardation is dependent upon the road adhesion of the rear tires, and of the foregoing power-absorption, about 0.6 of this should be taken up by the rear tires, the remainder being taken up by the front tires.

Fig. 7 assumes approximately constant deceleration, the cross-hatched portion at the left showing the power-absorption throughout the 2.5-sec. interval of the rear-wheel brakes, the stippled portion representing the resistance to rolling friction and retarding effort of the engine and transmission transmitted through the beveled gears directly to the rear wheels. It is further assumed that the rear-wheel and front-wheel brakes are adjusted equally; therefore the cross-hatched areas are the same. The stippled portion at the right shows the wind resistance which is applied directly against the car as a whole.

Fig. 7 demonstrates that, even though the power-absorption of the total braking-effort is 103 hp. with a constant deceleration, the brakes furnish only a fraction of this total effort, possibly 70 to 75 per cent, which is divided equally between the front and the rear wheels. Furthermore, the deceleration of the car is not constant, so that, in coming to a stop in 55.5 ft., the time taken is more than 2.5 sec., reducing the horsepower proportionately.

It is believed that giving more thought to the actual operations incurred in braking may be helpful to anyone considering this subject, and it also will be timely to illustrate a test conducted by one brake-lining manufacturer which took place on a long 7-mile steep-descent running into Yosemite Valley, Cal. On that hill a Packard Light Six car, equipped with the manu-

facturer's brake-lining, was driven all the way down with the clutch thrown out and with the foot brake doing the entire work of holding the car under control. The heat of friction developed on that descent burnt the paint almost to the hub on both drums of the car, yet the brake-lining was uninjured, as has subsequently been proved by the fact that the same set is in use today after having been in service for approximately 30,000 miles.

Misconceptions Corrected

MR. VON AMMON:—The interesting contributions by Mr. Weaver and Mr. Baer invite a reply of considerable length, but limitations of space dictate brevity and also suggest a joint reply to these two contributions. It is unfortunate that so much of the comment is based on misunderstanding of portions of my paper which seem to have been correctly interpreted by other readers, and on the quoting of disjointed portions, a practice that frequently is misleading.

My paper points out that, owing to its "heat-resisting" qualities, asbestos forms the basis of most present brake-linings. However, additions of other less "heat-resistant" materials now used, useful or necessary as they may be for certain reasons, not only reduce the heat resistance of the finished product to less than that of asbestos, but some of them also largely contribute, particularly at increased temperatures, to a lowering of the coefficient of friction, to the magnitude of the changes in the coefficient of fricton and to a reduction of the durability. The paper then suggests as a conclusion that "it is therefore preferable to use in the composition, if possible, only materials which will admit the full utilization of the qualities of the asbestos," and so on.

Mr. Weaver's and Mr. Baer's comments on the limited use of wire and, especially, cotton, confirms the correctness of this conclusion. The various comments and claims made in regard to saturants that are not affected by heat are interesting; but they are not convincing so long as such claims have, as stated in my paper, "not been or have only to a slight extent been substantiated by the materials so far investigated by us," including some allegedly unaffected by heat.

Contrary to Mr. Baer's opinion, at least some of the car and brake, as well as brake-lining, manufacturers have applied real endeavor and considerable thought to the design, material and other features of brake mechanism, drums and linings. As a result, the trend has been toward improvement in all these parts and my paper gives full credit for this. Among the problems to be solved is that of incorporating in the brake-linings a greater uniformity of performance than is indicated by a drop of the coefficient of friction to values of 0.20 to 0.10 or less, under certain conditions which may occur in service. This tendency, shown by our tests to be very general, requires that it be given consideration on a par with other factors that may contribute to inadequate stopping-ability.

My paper nowhere expresses the idea, as intimated by Mr. Weaver, that the coefficient of friction or the wear is solely attributable to the brake-lining and uninfluenced by the drum material. Definite reference actually is made to the fact that in the recent work we have used drums of the "same material, low-carbon steel, as used earlier," and that the new equipment is suitable for use with "drums of widely different materials and construction." The need for testing brake-linings with various drum materials is stressed.

As and when car builders or users conclude that the use of drums of special design or material with brake-linings more perfect than the present average product will offer sufficient advantages to make their use "commercially practicable" in spite of a possibly higher cost, there will be need of basing specifications on such combinations. Until then it is "reasonable to test linings offered or considered for general service conditions on the drum material least favorable to the durability of the linings, particularly if the drum material in most general use is of that class." If Mr. Baer had not, in quoting me, omitted the last part of my statement as shown above, he might not have been misled into believing that the method of testing proposed by me "naturally would be in the wrong direction and unfair to the brake-lining."

Mr. Weaver is correct in giving first place to the ability of brake-lining to stop the vehicle, and second place to the durability. The Bureau of Standards believes that among those brake-linings having satisfactory frictional characteristics—"the first consideration should be utmost reliability and uniformity under all conditions"—those possessing the greatest durability will be preferable as giving the lowest "cost of braking service." Unfortunately, tests made so far by us have demonstrated that the terms "satisfactory frictional characteristics" and "uniformity under all conditions" cannot, at present, be interpreted as strictly as would be desirable.

In my comment on the curves showing comparative wear-factors, quoted by Mr. Baer, the word "chiefly" should have read "partly."

Final Selection of a Brake-Lining

H. COPLESTON[9]:—The testing of brake-band lining by laboratory methods for acceptance by motor-car builders is unsatisfactory at present. I believe Mr. von Ammon is correct when he states that final selection of a brake-lining will be made after a series of tests has been made on the vehicle itself. It is unfortunate for the brake-lining manufacturer that the various speeds, pressures, rates of absorption and designs of brakes are very much unlike, as it does not permit him to make a universally satisfactory brake-lining which can be produced economically. In consequence, it becomes necessary for him to be well acquainted with the various possibilities of the product which he is manufacturing, and this necessarily calls for some suitable machine for laboratory use.

Advantage of the Carson Machine

There is similarity between the Bureau of Standards machine and the Carson machine in one point which influences the results obtained with these equipments to such an extent that it makes them questionable. I refer to the peripheral speed of the drum. We have not progressed with our laboratory work to a point where we have departed from the speed of 600 r.p.m., which is common with both. Considerable investigation of this factor is on our program.

The new Bureau of Standards machine has been refined considerably, but I note that a flexible band is still retained as in the former machine, which band does not give uniform unit-pressure, as it has been indicated that there is a certain amount of tripping or

[9] M.S.A.E.—Consulting engineer, automotive equipment department, Johns-Manville Corporation, New York City.

wrapping action of the band which causes uneven wear. This tripping action is caused by the rotation of the wheel and the tendency of the band and its supports to rotate about the point of support on the main frame. An effort has been made to correct this by fastening the entering edge, which naturally changes the pressure conditions existing over the band. In consequence of this construction, an average pressure is obtained; but the principal trouble with any testing equipment is the temperature at which it operates.

We find that the Carson machine approaches more nearly to operating conditions than does the Bureau of Standards type. This is caused primarily by the temperature at which they operate. A study of impregnations can be made on the Carson type of machine; but, with the Bureau of Standards machine, the temperature at which it operates is so high that the impregnation is carbonized in the first 5 min. of operation. It is commonly known that, with asbestos products, operating temperatures in excess of 700 deg. fahr. on brakes or clutches do not permit satisfactory operation.

Variation of Coefficient of Small Interest?

All the efforts in the past have been along the lines of a study of the variation in the coefficient of friction, which information, while interesting, is of no great importance except possibly as an occasional check on the variation. This checking has been done and we have all learned the variation in friction which occurs with various major types of material. In consequence, we can classify the material in the group wherein the variation of friction is known to a fair degree of accuracy. The greatest difficulty has been that the motor-car builder has insisted upon raising the coefficient of friction to values which are entirely unsuitable. Lower frictional values with higher pressures are far more satisfactory, because the coefficient variation is less and the squeak and water troubles are eliminated to a great extent.

The brake-lining saturants that are available are greatly limited in temperature and have the tendency when heated to reduce the coefficient temporarily. They must be used, however, to bond the asbestos fiber and to reduce the abrasive action of the asbestos as, at present, the limitation of the brake-lining manufacturer in increasing the resistance to wear of his products is largely fixed by the composition of the brake-drum in use. It is interesting to note, however, that the brake-drums are becoming better and that the motor-car builder is beginning to take an interest in the lower frictional values. I believe, however, that the motor-car builder is not so vitally interested in the variations of friction and other laboratory information as he is in the relative results of the use of the brake-lining on his particular construction.

Advantage of Intermittent Tests

Practically every laboratory machine which so far has been developed has been a machine which operates continuously, and this does not bring out one important point in the normal use of brake-linings. It must be remembered that an enormous shock is given to a brake-lining at the moment the vehicle comes to rest. There is also a very high temperature on the surface of the brake-lining which, when the brake is released instantly and exposed to the air, causes a chilling effect that has a peculiar action on the friction-lining surface and this greatly influences its rate of wear. This also is not brought out by equipment which operates continuously. In consequence, a testing machine that will be of the greatest value to all interested unquestionably will be a machine which has been developed to take the structure as the manufacturer produces it and which will function automatically as close to the normal operating conditions as is possible. This method brings out many points of interest in connection with the design of the brake structure, but I believe that this type of machine cannot be built except at considerable expense.

It is my opinion that the most useful type of machine for the development of a lining for any frictional service is one which operates on the intermittent principle, absorbing a fixed value of energy and the operating temperature of which is below the destructive value of the bonds which are available.

Mr. von Ammon:—In questioning the results obtained with both the Bureau of Standards and the Carson machines on account of the peripheral speeds used, Mr. Copleston evidently overlooks the fact that the Bureau has worked not only with 600 r.p.m. but also with lower speeds. My paper in particular gives results of tests at 300 r.p.m. and points out that the speed has much less effect on the behavior of the brake-lining, as evidenced especially by the coefficient of friction, than has the operating temperature. This information is based, not only on operation at different peripheral speeds, but also on tests at different power-absorptions and not only with the flexible-band brake-shoes, as used from the beginning of this investigation, but also with different rigid brake-shoes generally similar to the one illustrated in my paper and using specimens from 2 to 6 in. in length.

Equipment versus Test Conditions

Mr. Copleston's comments indicate that he confuses test equipment and test conditions. He states that his laboratory has worked only with one set of test conditions on the Carson machine. The fact that the operating temperature is governed chiefly by the test conditions rather than by the equipment seems to be ignored by Mr. Copleston in spite of much information in my paper. As I have pointed out, a full knowledge of brake-lining, or any other material, can be had only by subjecting it to a variety of conditions which cover reasonably well the whole range over which a knowledge of the material is desired. Perhaps it is necessary to refer again to the fact that the Bureau's "severe-service" test has never been considered as giving information under any but its very severe conditions. I have never considered that the severe-service test alone could give results that could be fully correlated with results in road service under all operating conditions. Some brake-lining manufacturers find it easier to so correlate results from tests with less severe conditions; but others have stated only recently that the severe-service test demonstrates the behavior to be expected on the road better than do the tests under more moderate conditions.

One advantage of lower speed lies in the fact that, with a given power-absorption, the lowering of the speed results in a proportionate increase in the unit pressure, while the operating temperature is raised only slightly. Thus, a given power-absorption at 300 r.p.m. requires, for the same coefficient of friction, double the unit pressure as does the same power-absorption at 600 r.p.m.; but, with the present Bureau of Standards equipment, the equilibrium temperature is only about

20 per cent higher at the lower speed due to the reduced windage.

The work done at the Bureau of Standards throughout 1927 is yielding information which it is believed constitutes a more complete knowledge of brake-linings than that previously had; and it may be that the tentative test-schedule now being tried out on numerous samples, representative of different types of brake-lining in use, will prove a fairly satisfactory basis for a general rating of linings, at the same time requiring less time than do the severe-service tests. A schedule for this purpose should be as simple as possible and the brake-lining manufacturer desiring to improve his product will no doubt find it desirable to elaborate the test schedule. The Bureau of Standards equipment will, I believe, prove a very useful tool for this work in the laboratory.

I find myself in disagreement with Mr. Copleston's statement that

> All the efforts in the past have been along the lines of a study of the variation in the coefficient, which information, while interesting, is of no great importance except possibly as an occasional check on the variation.

The efforts have in general been very much occupied also with the durability of brake-linings. The study of variations in the coefficient of friction is, I believe, also of considerable importance. In fact, if such study should lead to the production of a brake-lining having a uniform coefficient of friction over the whole range of operating temperatures and other conditions met, I believe the producer of such a lining would, as a result, find himself amply rewarded.

With regard to test equipment of the intermittent type and its value, I refer to the information and opinions offered in my paper.

Agreement as to Methods of Testing

Comment on my paper received from the chief engineer of a prominent company which manufactures brake-linings is to the effect that an agreement as to methods of testing is highly desirable but that a word of approval from a manufacturer of brake-linings is reason for condemnation in the minds of many of the car builders. My reply is that, under present conditions, any agreement as to methods of testing can be tentative only. This is necessarily true on the one hand because of our incomplete detailed knowledge of the characteristics of brake-linings and of the requirements of brakes, and on the other hand because, with changes in traffic conditions and improvements in brake design, the requirements are undergoing rapid changes and we know little of the possible improvements of which even asbestos brake-linings are capable. However, increased knowledge of both brake design and brake-linings will bring car builders and brake-lining manufacturers into better agreement.

Army Motor-Transport Operation Activities

THE operating formations of Army motor-transport that are controlled directly or indirectly by the Quartermaster Corps are the various trains pertaining to divisions, corps and armies, and the general transportation elements in a theater of operations or in the zone of the interior, including transportation at posts, camps, stations, depots, and similar installations.

The supply and maintenance activities are divided into three classes—service parks, overhaul parks, and reconstruction parks—that function as a progressive system of repair from front-line positions to the back areas, graduated for rapid evacuation and repair at places best fulfilling all the conditions that are attendant on the nature of the repair.

In brief, service parks are designed to make light repairs, not requiring heavy equipment, and are located wherever there is motor-transport activity. Overhaul parks are primarily for the repair of units requiring work of a nature beyond the repair facilities of a service park. A reconstruction park is intended primarily for the reconstruction of vehicles and assemblies, the necessary manufacturing production work that may be necessitated by military conditions, and for the classification, disposition, or remanufacture of all salvaged motor-transport materiel.

The distinction between the character of work performed by the overhaul park and the reconstruction park must be determined by the particular conditions in the military operations. In reality, the overhaul park is that link in the supply and repair system needed to give it the flexibility that is essential in a military organization.

The specific maintenance system is known as the Unit-Repair and Replacement System. In brief, vehicles are repaired in the field by replacement of units, which are then sent to shops for repair and reissue. In other words, the normal practice is for shops to repair assemblies and not complete vehicles.

At the present time, the service parks, which are scattered throughout the corps areas and departments, function under the direction of local commanders, while the reconstruction parks, which are at Camp Holabird, Camp Normoyle, Jeffersonville Quartermaster Depot, and the San Francisco Depot, are under the direct control of the Quartermaster General. In each overseas department is a shop that approximates an overhaul park, directly under the control of the Department Commander, but the need for the link in the maintenance system typified by the overhaul park is elsewhere practically non-existent in peace time.

To indicate the extent of the maintenance work in these reconstruction shops alone, during the fiscal year 1927 over 2700 vehicles, 110,000 units, and some 3500 miscellaneous jobs were handled at a cost of approximately $522,000, which would have cost well over $1,000,000 if handled commercially. The work of all the other repair activities, such as the service shops and those overseas, was about three times greater, with corresponding savings over commercial costs.

In addition to the current work in connection with operation and maintenance, much study is being given to the development and test of motor-vehicle types for different classes of military service. These activities are being much increased on account of the investigations now being conducted by the War Department relative to the mechanization of the Army.—Brigadier-Gen. F. H. Pope, in *The Quartermaster Review*.

Production and Wage Plans at an Equipment Factory

By C. E. Wilson[1]

Indiana Section Paper

Beginning with the contract relations with their customers, the author outlines the procedure for production planning, purchase control and wage payments at the Anderson factory of the Delco-Remy Corporation.

Working on the basis of monthly schedules, instead of annual contracts for definite quantities, has made possible a great increase in rate of turning over material.

Many wages are paid on a group premium basis, a modification of the Bedaux system, that has proved very satisfactory and adaptable where operations are not distinct or independent enough for individual premium wages. Several such groups are described.

The discussion, which was almost all on wage payments and allied subjects, brought out one instance in which men had produced even more than the theoretical capacity of their machines.

Wage premiums for foremen, inspectors, toolmakers and tool designers came in for discussion.

American flags are made more effective than gear guards in preventing accidents. Boys and men are being trained for greater usefulness, mostly in cooperation with the local high school and various colleges.

PRODUCTION schedules of the Delco-Remy Corporation must be laid out with reference to the requirements of our customers, the motor-car manufacturers. Years ago we would get a contract from an automobile manufacturer for 5000, 10,000 or 50,000 sets of electrical equipment, the quantity the company expected to use during the year. We would buy material in the market on the basis of that contract and start to fabricate parts. In those days we had a very large inventory with relation to our monthly shipments, and serious losses from cancellations and engineering changes resulted. Usually our customer wanted either twice as many or about a tenth as many units as he thought he would take. So this was found to be a poor way to run an accessory business.

Now we do not ask our customers to give us a contract for a definite number of units during the year, but simply to assure us that their business is ours and that whatever they need they will buy from us. We tell them that we are in the automobile business with them; that we will take care of their requirements and will not complain about short schedules or about having too much to do on short notice. We appreciate, however, all the help we can get in forecasting our schedules. The first of each month we make a production schedule for that month and for the 2 months following. These schedules have two columns: one showing shipments, and the other showing the relations to the production departments of the factory. At certain times of the year we build ahead of schedule, to eliminate a quick increase in production and also to give our employes something to do in the slow time of the year, in November and December.

Our production schedule is broken down into parts and finally into raw material, and requisitions are placed on the purchasing department by the material control section. The purchasing agents usually buy material of a standard nature, that can be obtained from suppliers on short notice, by the month. Other materials, such as the Swedish diaphragm steel used in some of our horns, must be purchased 6 months ahead. The time for getting in materials and the quantities purchased ahead are left to the production manager and the purchasing agent.

To make our operations a little clearer, I will explain what might be called our organization chart. We have a factory manager, sales manager, chief engineer, production manager, chief inspector, service manager, comptroller, and personnel director. These heads of departments report directly to the general manager and have control of all of the activities of the company.

The factory manager is concerned with equipment, processes, expense of operations, and personnel organization and is responsible for having at all times the equipment and the capacity to take care of the schedule.

The production manager, working from the production schedule, is responsible for our inventory and for seeing that the equipment is shipped when the customers want it. He has complete control of all materials and stocks until the final shipments are made to the customer. The purchasing is also under the production manager in our organization, which I believe is a little unusual.

Our bogey for inventory turnover is 12. In other words, the average annual sales should amount to 12 times the average value of the raw material, work in process, and finished stock. That is many times better than it used to be under our old system of purchasing and production.

The chief inspector in our organization has somewhat heavier duties than usual. He reports to the general manager, rather than to the factory manager, and is responsible for the quality of the incoming material, of the parts and of the finished product in the plant.

[1] M.S.A.E.—President, Delco-Remy Corporation; president, Klaxon Co., Anderson, Ind.

He is also held responsible for seeing that action is taken on all complaints from our customers' plants regarding the quality of our production, whether it involves engineering action or a change in the factory methods or is merely a slip on the part of his own inspectors. The sales manager, chief engineer and comptroller have the usual duties that the titles imply.

Premium Wage Plan Employed

The wage-payment plan in any organization is an important question. In Anderson we have a modification of the Bedaux system. The original Bedaux system is a premium system which provides for time studies of all operations and for setting standards, so that, on the average, the operators make about 35-per cent premium. The Bedaux system provides for paying the operators a premium for 75 per cent of the production above a certain definite standard. In other words, if normal production on a part amounted to 100 per hr., the operator would be paid the base rate for that production. If the production were increased to 150 per hr., the operator would be paid the base rate plus 75 per cent of the extra 50 produced, or 1.375 times the base rate.

This Bedaux system was introduced in the Remy company about 8 years ago. Since then it has been modified by applying it to groups of workers, in many cases, instead of to individuals. We believe in the group method of wage payment for premium work in three classes of production: (*a*) progressive production-line operations, (*b*) work done by skilled labor with helpers and (*c*) work in which operations cannot well be divided and checked.

Where the work is naturally progressive, each man performs an operation on a piece that is passed to him from the preceding operator and the amount of work he can do is really limited by the number of pieces passing through the group. Good examples of this type of production are motor and generator assembling, where the machines start at one end of the line in the form of frames and the parts are added to them, each man performing his operation as the parts come along. Motor armature production is another good example of progressive work.

Group Effort Rewarded with Group Premium

The second class of work which we believe in grouping is that in which operators can actually help one another in their work, so that a highly skilled man can do the more difficult part of the work and less skilled operators can help in the group. The best example of this type of work is in the automatic screw-machine department. According to our old method, there was a set-up for each battery of machines. An operator was assigned to certain definite machines, for instance, he might be running three Acme screw-machines, and the set-up men changed the jobs on these machines from one piece to another and took care of trouble that might occur in the production. This set-up man had no particular responsibility for the production, and the operators, when a machine was in trouble, were allowed a certain amount for the machines being down. The result was a decreased production from the department and a general controversy between the set-up men and the operators.

Our present system consists in grouping a set-up man with the operators to handle a given number of machines, perhaps 15 or 20 machines. The set-up man is paid a premium along with the operators on the total production from that group of machines. If the group operating these machines has much trouble, the operators will pitch in and try to get as many machines running as possible, and temporarily one man may stock five or six machines instead of the three machines which he would normally operate.

When day and night forces operate the same group of machines, the day and the night men are included in the same group so there is no controversy about who ran down the tools and who ground them and who spoiled the set-ups.

The improvement made in our production after this group system was satisfactorily working in our automatic screw-machine department was surprising. The operators all made more money than they had ever made before, the capacity of the department was materially increased, the quality of the work was improved also and there was no questioning about which group made certain pieces on account of the group being paid only for good work. The net result has been very satisfactory.

The third class of work which we believe in grouping is work of such a nature that it is very difficult physically to keep track of the individual operations performed by the operators in the department. An example is the plating department. There operators are grouped and the total number or pounds of plated pieces is checked out of the department and standards are set on the basis of the total production from the department. No matter whether a given operator is washing pieces or cleaning them or stacking them on racks, the men all pitch in and do whatever work is at hand to be done, knowing that if each does his part they can all make money from the total production of that department.

Individual Rewards Better in Some Work

In work such as generator armature winding, grouping does not work quite so well. In this class of work a number of operators are doing exactly the same operation. The time required is enough so there is no difficulty in keeping count of the number of pieces produced by each operator. The work also is such that it is necessary to follow the work of individual operators for quality. While the girls are learning to wind armatures they do not do as well as experienced operators and it is necessary to follow their work, to see that they are winding armatures well and that their production is increasing as it should.

Where a complete department has been grouped, or practically a complete plant, this type of work also was grouped. The only way we can group such operations with any satisfaction is to break up the large group into three or four smaller groups, keeping track of the individual operators and classifying them according to the quantity of their production. In this way, the experienced operators are not penalized by the low production of beginners. Even then these groups are not nearly so satisfactory as groups of the first three classes described, and we group work of this type only when it is part of a big production set-up and practically all other work is grouped. Then we group it from the point of view of the whole production rather than of the efficiency of that particular operation.

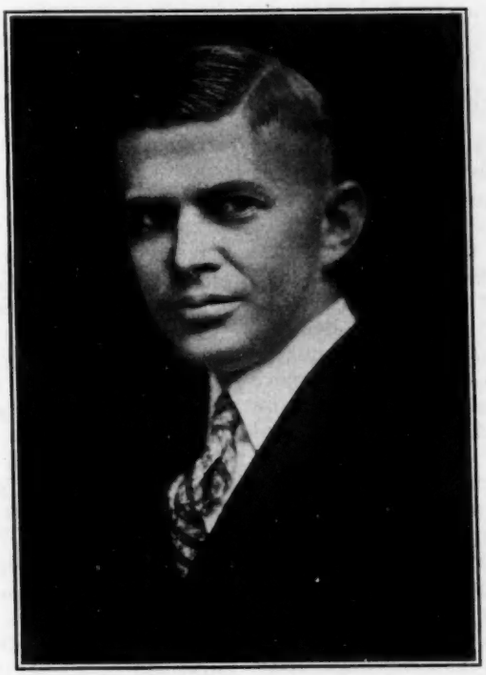
One of the important things in the progressive manufacture of interchangeable parts is to have accurate time-studies on all operations. At present 99 per cent of the labor in our plants is standardized. By that I

mean that it is paid for on a premium basis according to the time studies. With such a complete standardization of the time of operations, it is possible for the factory manager to judge whether or not he has sufficient equipment and for the production manager to forecast properly the production requirements and to make promises of deliveries to the customer that will be fulfilled.

THE DISCUSSION

H. T. BLASINGHAM[2]:—Have you any way of allowing the foremen to participate in the bonus?

C. E. WILSON:—As originally applied to our plant the Bedaux system did include a provision for foremen's bonus. I mentioned that the operators receive 75 per cent of the premium. The original Bedaux system provided for a distribution of the other 25 per cent to the non-productive operators of the department. We found so much difficulty in distributing this extra premium equitably that after about a year we discontinued the practice. I believe that, where it can be properly worked out, it is a good thing to have the foremen participate in some bonus or premium based on the production and expense of operating their departments. A set-up that would give a foreman a large premium without any relation to other than the production from his department probably is not worthwhile.



C. E. WILSON

C. A. TRASK[3]:—You have told about the bonus system for the operators. I saw many evidences of very clever work of machine and tool designers in your plant. Are they compensated for this work by a flat salary, or is a premium paid to them?

MR. WILSON:—We have no method of compensating tool designers, engineers or superintendents other than by their salaries when their work is what would be expected from the particular man or department. We have a suggestion system in the plant whereby operators or employes are compensated for suggestions they make along lines other than what normally could be expected of them. This suggestion system is intended particularly for operators in the plant in connection with their own operations. It is handled by a committee with representatives from the standards department, the engineering department and the personnel department. The suggestions are classified and the operators and employes making them are compensated in proportion to the dollars saved in production by their suggestions.

W. G. PRAED[4]:—With the improved and intensified methods do you find the cost of inspection increased?

MR. WILSON:—Progressive manufacture has decreased the cost of inspection, partly because defects show up more quickly as the part passes from operation to operation and not so many defective parts are made before an inspector finds it out. In many cases the part is inspected only as it comes from the group. As only good finished parts are paid for, it is to the advantage of any operator to throw out a part that seems defective at any stage in the production operation. Mr. Van Meter might add something to that.

M. E. VAN METER[5]:—Inspection is time-studied and standards are set as on production, but no premium is paid. We tried to pay a premium at one time but it did not work out successfully.

MR. BLASINGHAM:—Are your operators paid on a basis of money per operation, or minutes per operation?

MR. WILSON:—On the basis of minutes. We call a normal low production for 1 min. 1 point. That is a unit of work, and when an operator does what amounts to 60 points per hr., he is paid only his base rate. If he performs operations that amount to 90 points per hr., he makes 1.375 times this base rate.

MR. BLASINGHAM:—That gives a chance to fluctuate rates without ever changing your hourly standard.

MR. WILSON:—Yes, and we find it a very flexible and successful system because sometimes an operation will change from a type of work that can be performed by a man to work that can be performed by a boy or girl whose base rate is different. We also have a much lower base rate for a beginner than for an experienced operator.

SLOW INSPECTION INDICATES TROUBLE

I might add to Mr. Van Meter's comment that inspection operations are time-studied largely to give a gage of the efficiency of operation of the inspectors. For instance, the final inspection of an armature is time-studied and, if the armature inspectors do not pass the normal number of armatures in a day, it is the duty of Mr. Van Meter or some of his assistants to look into the matter. Either the inspectors are not working or they are having an abnormal amount of trouble that requires attention. So he has a special set-up in his office for reporting the output of inspectors. We pay the inspectors no premium because we feel that it is not conducive to good work. When we paid a premium on inspection work we sometimes found that an inspector was tempted by the money to forget the reason why he was there.

QUESTION:—In the case of automatic screw-machines,

[2] Factory manager, Indiana Truck Corporation, Marion, Ind.
[3] M.S.A.E.—Equipment efficiency engineer, Rockwood Mfg. Co., Indianapolis.
[4] Assistant superintendent, Link Belt Co., Indianapolis.
[5] Chief inspector, Delco-Remy Corporation, Anderson, Ind.

where the maximum output is timed by the number of revolutions the machines make per hour, what per cent do you use for your normal low production?

MR. WILSON:—The maximum theoretical production from the machine would make 100 points per hr. or 50 per cent premium. We used to think that an operator could make only about 80 points per hr., 80 per cent of the theoretical production, which would pay 25 per cent premium, but we were astonished at one time to find groups in the automatic department running more than 100 points per hr. and we found that, although the night shift did not have a complete force to operate all the machines, it did run them, so the total production from that group was much more than normal.

QUESTION:—Has anything been done or any thought been given to placing toolmakers on the individual or the group premium plan?

MR. WILSON:—I have thought about it a great deal. The difficulties are that we do not have enough repetition work and that to properly inspect the product of a toolmaker is sometimes quite a problem. If too much incentive were put on the time required to make a particular die or tool and that resulted in an inferior product, it would be very difficult to handle the situation. A man might work on a die for 1 month and spoil it if he got in too much of a hurry, and then nobody would know what to pay him for it. Besides, it might cause dissatisfaction if some toolmakers worked on a premium and made 25 or 30 per cent more than others because they happened to be working on something like lamination-dies, which is a continual job for perhaps a half-dozen men.

I have thought of a system which I know to be used in some plants where the tool-design department or some one under the master mechanic estimates on all tool work. The toolmakers are paid a day rate, just as they are in straight time, and in addition are paid for half of the time they save under that estimate. If they take longer than the estimate they are not penalized. In other words, the company and the man share in any saving he can make under the estimate, and the saving made by the company is partly offset by the additional inspection required. I would be glad to hear any one else discuss that problem.

SAFETY ENGINEERING AIDED BY PSYCHOLOGY

COURT ROLLINS[6]:—In going through your plant, I noticed that you have many safety signs and posters in the shop, and that you have guarded your machines very closely. How long have you been applying safety methods extensively, and have you any figures to show your savings or increased production through them?

MR. WILSON:—We have been working intensively on the guarding of machines for about 8 years and found that, while guarding helped, it is only a small part of the problem. We continued to have accidents that were really due to carelessness and lack of appreciation of hazard on the part of employes; and we found that, to get the best results, we had to combine an educational campaign with the mechanical safeguarding of dangerous equipment.

The most effective thing we have done is to give each plant an American flag that flies only during a month when that plant has no accidents. The boys do not like very well to have their flag pulled down, and it seems to have resulted in more attention to safety than anything else we have tried and has built up an effective spirit of competition between our different plants. Mr. Huston might be willing to give us some figures on our recent accident reports as compared with previous ones.

C. A. HUSTON[7]:—It is the individual himself who has to enter into this problem to make safety really worthwhile. This flag floats over the building until an accident happens, and then it is taken down. In addition, in each department we have a sign, "100 Per Cent Safe," that also comes down when an accident happens in a department. Last month we had only one lost-time accident, and that was due to a girl who got a piece of wire or something in her eye and went to the first-aid department for treatment and failed to report for work the next day. That was the only lost-time accident we had last month. We find it works very well. Probably the safety engineer can give you figures on it.

FOREMEN HELP MEN TO AVOID LOST TIME

F. G. DEWEY[8]:—We had been losing possibly 100 to 600 days each month. As Mr. Huston said, we had only one accident last month. That is the best so far as I can find any records of the Remy or Delco-Remy organization at Anderson.

Our plan creates a competition between the plants and departments. Before, if the operator had a minor accident, he would go home even if he was able to work and possibly would be off for 2 or 3 days. Many times the foreman would not know about it until we notified him, as he did not check up very closely. Since we have the flag system it is different. We had it about a month before it took effect, and the effect was very noticeable. Now, when an operator is hurt, the foreman is right after him to see what is the matter and whether he will be back.

We have a full-time doctor and a trained nurse for first aid in all the plants and we let our doctor decide whether the man is able to work. If he has a foot injury and there is a job he can do efficiently sitting down, he goes back. Generally the foreman has a job for him by the time he gets first aid. I have checked up a number of these cases to see whether or not these men were earning their salt and I have not yet found 1 case out of about 25, from a broken finger on down, where it did not work out well.

MR. WILSON:—I did not realize quite the extent of that, but I know that we have made very material strides toward safety in our plants. More than 50 per cent of the accidents cannot be prevented by safety appliances alone. Fully half of the accidents in an ordinary plant can be eliminated only by getting everybody thinking safety, and I can recommend this flag idea wherever it can be used.

CHAIRMAN GEORGE H. FREERS[9]:—Do you find it hard to get skilled labor in a city of the size of Anderson? Do you have an educational department where you train your operators, or do you train them in the regular plant? Some plants have a small department, with one or two machines of a kind, where they educate the operators before placing them in the regular production line.

MR. WILSON:—So far as the production operators in the plant are concerned, the operations usually are such that we can hire people and put them into the production lines with reasonable success. We do have an ap-

[6] Warner Gear Co., Muncie, Ind.

[7] Personnel director, Delco-Remy Corporation, Anderson, Ind.

[8] Safety engineer, Delco-Reny Corporation, Anderson, Ind.

[9] M.S.A.E.—Assistant chief engineer, Marmon Motor Car Co., Indianapolis.

prentice set-up for training boys and young men for tool work. In fact, we have a part-time arrangement with the high school in Anderson, so that the boys who are specializing in manual-training work spend half of their time working in this special apprentice department and the other half of the time in school. We have found that boys who have had this training with us make more satisfactory toolmakers and are better satisfied with their work than toolmakers from Cincinnati, Dayton or Detroit. I believe very much in that program.

MR. HUSTON:—We have no trouble in getting skilled help. We have been using for some time the educational program that Mr. Wilson has mentioned and have found it very successful. We often place in our apprentice course high school graduates employed in our plant who show mechanical ability. We find this works very successfully. After a year we can place these boys in our toolroom, where they make very good apprentice toolmakers. There are now about 25 boys in our apprentice toolmaking department. The same method is carried out in our drafting room, and we find it pays to take young men and put them in training for automatic screw-machine operators.

CHAIRMAN FREERS:—Are these boys paid a small salary while going through this apprentice course?

MR. HUSTON:—Yes; it increases according to a regular scale through a period of 3 years.

MR. WILSON:—We have also seven pairs of boys from Antioch College, who alternate with their school work, and I believe we have in Dayton some boys from Cincinnati. We are sending 10 men to the new General Motors Institute in Flint, who work in our Anderson plant half the time. These men have ambitions to get a little farther than a skilled machinist or a toolmaker. We have told some of the boys who have this part-time arrangement in high school that, if they save all the money they make during their high school time, it will give them an excellent start if they want to go farther. They are living at home and they are that much ahead of the boy who goes to high school and does not go to work until he finishes school.

Service-Station Growth

THE service establishments of this Country now number about 86,000 and are taking care of over 22,000,000 motor-vehicles, or an average of 256 cars per shop. Five years ago there were only 182 cars per shop, showing that cars in use have increased faster than places to take care of them. That is a desirable condition, for the more work a shop has to do the more efficiently can it do the work.

In the same period engine upkeep expense has been decreasing. The average cost of operation and maintenance, excluding depreciation and garaging, is now $219 per car per year, as against $281 in 1919. This is in spite of the fact that the item of fuels and lubricants has increased, showing a higher average mileage or greater use of cars.

Repair shops now are giving employment to 450,000 people. The annual expenditure for parts, service supplies and service labor is $1,810,000,000. Labor is 58 per cent of this. This indicates that further economies may be effected through wider use of special equipment, for at present 52 per cent of our service-stations have only hand tools. The unfortunate situation is that the average service-station has not enough work to afford very much mechanical equipment.

The larger cities can and do have well-equipped service-stations, but only 11 per cent of the motor-vehicles in use are in cities of over 500,000 population. The suburban and rural sections, where more of the cars are owned, have very inadequate service. More than 64 per cent of the cars are registered in towns of under 25,000.

A hope for the future is such a set-up as will make possible a nearer approach to factory methods in maintenance. For example, regional repair factories serving all retail service shops within a radius of 10 miles, doing for them all repair and reconditioning work except such minor repairs and adjustments as the car owner would expect to have done while he waits. A very large part of automotive service should be manufactured instead of custom built.—H. R. Cobleigh in *Automotive Daily News*.

How Trade Associations Serve Industry

TRADE associations, of which over 280 are in existence in the United States at the present time, appear to have started originally as credit reporting agencies. In such form they were served by a secretary with probably one assistant and occupying only a tiny office. From this modest beginning they have taken on one form of work after another until today they are engaged in such widely diversified activities as gathering trade statistics, conducting testing laboratories, improving trade ethics, investigating possible markets, opposing unfriendly legislation, educating retailers, and preparing advertising to reach the ultimate consumer.

Much of this work has been of far-reaching benefit to the industries supporting it. Desirable objects which a single manufacturer would have found impracticable by reason of the large expense involved have been accomplished cooperatively. How far an association can go without becoming unwieldy and increasing its expenses to the point where the industry will refuse to support it is a question that is troubling the officers of many of these organizations.

The statement is sometimes made that American business is over-organized. That is true to some extent but it also applies to the world at large where societies and clubs have been organized for the advancement or amelioration of every condition known to man. Nevertheless, the benefits of cooperation within a given industry have been so plainly demonstrated that any substantial retrogression is not likely to occur. The present problem is to keep association work within reasonable and practical limits and to render the maximum service which the individual members will readily recognize as worth every penny invested in the form of dues.—Robert L. Thalheimer, in *Printers' Ink*.

The Wright Brothers Medal

Rules for Award Announced by Committee Consisting of Chairman J. H. Hunt, Hon. E. P. Warner and Dr. George Lewis

THE Council of the Society has just approved the following rules for the award of the Wright Brothers Medal submitted by a special committee appointed to study the situation.

Rules for the Award of the Wright Brothers Medal

The Wright Brothers Medal, originally donated by the Dayton Section of the Society of Automotive Engineers, shall be awarded annually to the author of the best paper on aerodynamics or structural theory or research, or airplane design or construction, which shall have been presented at a meeting of the Society or any of its Sections during the calendar year. If in the opinion of the judges there has been presented during a given calendar year no paper dealing with these subjects and worthy of an award, the judges may award the medal for that year to the author of the best paper on any other aeronautic subject.

The award shall be made by three judges appointed by the Council, each judge serving for a term of 3 years and the term of one judge expiring each year.

The members of the committee of judges shall not be eligible in the competition.

No one person shall win the medal twice within any period of 4 consecutive years; that is, 3 years must elapse after award of the medal to a given person before he can again be considered eligible.

Papers presented at the Society and Section meetings shall be judged primarily for their value as new contributions to existing knowledge of the aeronautic art. Judgment shall be based upon the value of the paper itself as such an original contribution, not upon the value of some mechanical development or invention already known which the paper may describe.

The first award under these rules shall be made for the calendar year 1928.

History of the Wright Brothers Medal

The Dayton Section of the Society originated the idea of awarding a Wright Brothers Medal having the double purpose of honoring the first successful constructors and operators of heavier-than-air flying-equipment and of encouraging the presentation before the Society of the results of new development in the form of engineering papers.

The Dayton Section offered the medal in competition for the calendar year 1924, the conditions of the original award being covered by the following statement:

The Dayton Plan

To commemorate the pioneer aeronautic achievements of the Wright Brothers, the Dayton Section of the Society of Automotive Engineers will award a medal annually for the most meritorious paper presented to them during the year, reporting an original contribution to aeronautic science. The award will be for the intrinsic merit of the contribution made, rather than for literary merit of the paper describing it. The contribution to or discovery in aeronautic science and art may include advances in the theory of aerodynamics or in the experimental technique, developments in the analysis of airplane structures, or improvements in the construction of airplanes, powerplants for same, accessories which increase their efficiency or reliability, such as fuel systems, control mechanisms, aerial navigation instruments, and the like. Improvements for military application, ordnance, aerial photography, and the like are ineligible to competition for this award. In those cases where the contribution described is in the nature of an invention or mechanical device, flight tests are desirable, and papers including complete reports of them under proper conditions in the presence of unbiased observers are advantageous to the competitors. Flight tests will not be absolutely insisted upon, as these might be financially impossible for individuals, though the proposed improvement would be clearly evident to a competent award committee. Complete technical information regarding the contribution must be included in the paper.

Competition for this prize is open to any individual citizen or group of not more than two individual citizens of any country, excepting that National officers of the Society of Automotive Engineers and officers of the Dayton Section of the Society of Automotive Engineers, Contest Committee members, and Award Committee members are ineligible.

Papers should be plainly labeled with the author's name and address and forwarded to the Wright Brothers Medal Committee, Dayton Section of the Society of Automotive Engineers, care of Engineers' Club of Dayton, Dayton, Ohio.

The Award Committee, which will select the winner of the competition, will be appointed annually by the Section Contest Committee.

The paper describing the achievement for which the medal is awarded shall be presented for the first time before the Dayton Section of the Society of Automotive Engineers, either by the prize winner, or, if this proves impracticable, by some member of the local Section appointed by its officers.

The award for 1924 shall be based on papers received up to Dec. 31, 1924, and shall be announced as soon as all papers and data therein can be checked. The Dayton Section of the Society of Automotive Engineers reserves the right to withhold any award if the Award Committee finds no paper submitted of proper standard.

The Dayton Section of the Society of Automotive

Engineers reserves the privilege in future years of restricting the competition to a narrower field of endeavor than is announced for 1924. However, any such restrictions shall be announced by Jan. 1 of the year during which they are operative.

Several papers of a very high grade were received as a result of this competition. In the opinion of the Board of Judges, none of these papers complied completely with all of the requirements, and no award was made.

Last summer the Dayton Section asked the Council to undertake the administration of the award of the medal. The Dayton Section was greatly influenced in taking this position by the fact that a very large percentage of its membership is engaged in aviation work. This situation might at some time be a cause of embarrassment in connection with the handling of the competition. The request of the Dayton Section has been granted by drawing up the present rules.

The design of the medal, shown in the picture on the preceding page, was prepared and the die cut by Adam Pietz, of Philadelphia. Theodore H. Pond, of the Dayton Museum of Arts, assisted the Dayton Committee in its work toward the development of the design.

Purpose of the Award

Provision for the award of this medal should encourage men doing development work in aeronautics to present the results of their work in the form of engineering papers before our Society. The medal itself will provide the successful competitor each year with something a little more tangible than the satisfaction which comes with the accomplishment of good work. The award enables the Society to show in a very definite way our sincere desire to contribute to the progress of aeronautics by the presentation for discussion of papers of the highest grade.

Finally, but by no means least, we make a small demonstration of our admiration for the genius of the Wright Brothers, who first solved the problem of mechanical flight.

The Right-Hand Rule

MANY step into an automobile and drive out upon our public highways without one thought about their legal status except to keep out of an accident and avoid a policeman's summons. How much better it would be to keep abreast of the rules and avoid all difficulty. The right-hand rule should be understood by all because it is vastly important.

Some drivers still think the rule is that up-and-down-town traffic has the right of way over the crosstown traffic. This is no longer so. Where there are signal towers or a traffic officer these two instrumentalities of right order prevail; but the right-hand rule should be the guide at an intersection where there is neither a signal light nor a traffic officer.

To put it in its simplest phraseology, the right-hand rule, as has been judicially interpreted, provides that where two vehicles are approaching an intersection of two streets, the driver who is proceeding from the right of another has the right of way. This does not mean that, when you are 10 ft. from an uncovered intersection and notice a vehicle approaching from your right, this fact alone requires you to stop until the other passes. The other car might be 400 or 500 ft. away and you might have ample time to cross. Nor does it mean that the intersection is to be considered as the dead center of the two streets, because both vehicles are expected to keep to their right of that point. The rule as interpreted means this: When two drivers are approaching an intersection from north and west, the driver proceeding from north to south must give the right of way to the driver proceeding from west to east when it would appear that if both continued toward the intersection without changing their speeds there would be a collision.

For example, if A is proceeding from west to east on First Avenue, which is 200 ft. wide, and B is proceeding from north to south on First Street, which is 200 ft. wide, B must give A the right of way if it appears that by continuing a collision would result. A might be 10 ft. from the curb line and B might be the same distance from the curb line. A collision then would occur at a point in the intersection of First Street and First Avenue where two lines at right angles to each other and each 10 ft. from the curb would meet, or about 14 ft. from the southwest corner. And yet both cars would be west of the center point of the intersection.

Now let us suppose that both A and B are driving 10 ft. from the left curbs. In this case the accident would occur diagonally across the intersection, that is, instead of near the southwest corner, the accident would happen near the northeast corner; but the right-hand rule would prevail, prescinding at all times from negligence on the part of both which would alter the liability and with which we are not concerned here.—Frederick A. Fullhardt, in *New York Motor News*.

Cost of Research

APPROXIMATELY $200,000,000 is being spent annually in the United States for industrial research by corporations and the Government, with industry spending $2 for every $1 spent by the Government. So rapid has the extension of research work as a necessary auxiliary to industrial management and technique been that more than 1000 organizations have research departments in operation at the present time as compared with 578 companies which in 1921 were known to maintain research departments or laboratories. In addition, 70 trade associations are spending approximately $15,000,000 per year in research and 152 colleges and technical schools about $1,500,000. Much technical research work is also being carried on in connection with industrial production, the costs of which are not segregated as such but are accounted for as part of production costs and hence are not included in the total sum mentioned.

Industries whose research expenditures were largest 5 years ago are those that have made the greatest relative growth since then. The greatest amount spent by any single manufacturing company in a year was more than $5,250,000, while a public utility corporation spent approximately $13,000,000 in the same time. The average amount spent on research by manufacturing companies is from 1 to 3 per cent of the gross amount received from sales.—National Industrial Conference Board.

Automotive Research

(*Continued from p.* 313)

means of the "spread demand," both horizontal and vertical. The "spread demand" may be defined as the total angular displacement made by a target on a preceding car with respect to the axis of the following car, while the first car remains in the field of vision. The spread demand, both horizontal and vertical, will be affected by road roughness, spring flexibility, speed, distance between cars, and other factors.

The apparatus employed consists of two cars, Car *R* having an illuminated target, shown in Fig. 12. A camera is rigidly attached to car *S* as shown at *Q* in the upper right view of Fig. 11. Means are provided for rotating the camera about either the vertical or the horizontal axis of the mounting. The camera controls are within reach of the operator.

Car *R*, with target illuminated and all other lights on the rear extinguished, is placed in line with Car *S* at a distance of 100 ft. from it, with no lights on Car *S*.

With the camera firmly locked in place and the shutter open, Car *R* precedes Car *S* at a distance, as nearly as may be maintained, of 100 ft., at any predetermined speed.

The character of the country to be covered may vary as widely as the nature of the variation of the terrain permits. The duration of the exposure may be varied at will.

The calibration was obtained by exposing successively the target on Car *R* when displaced horizontally at distances

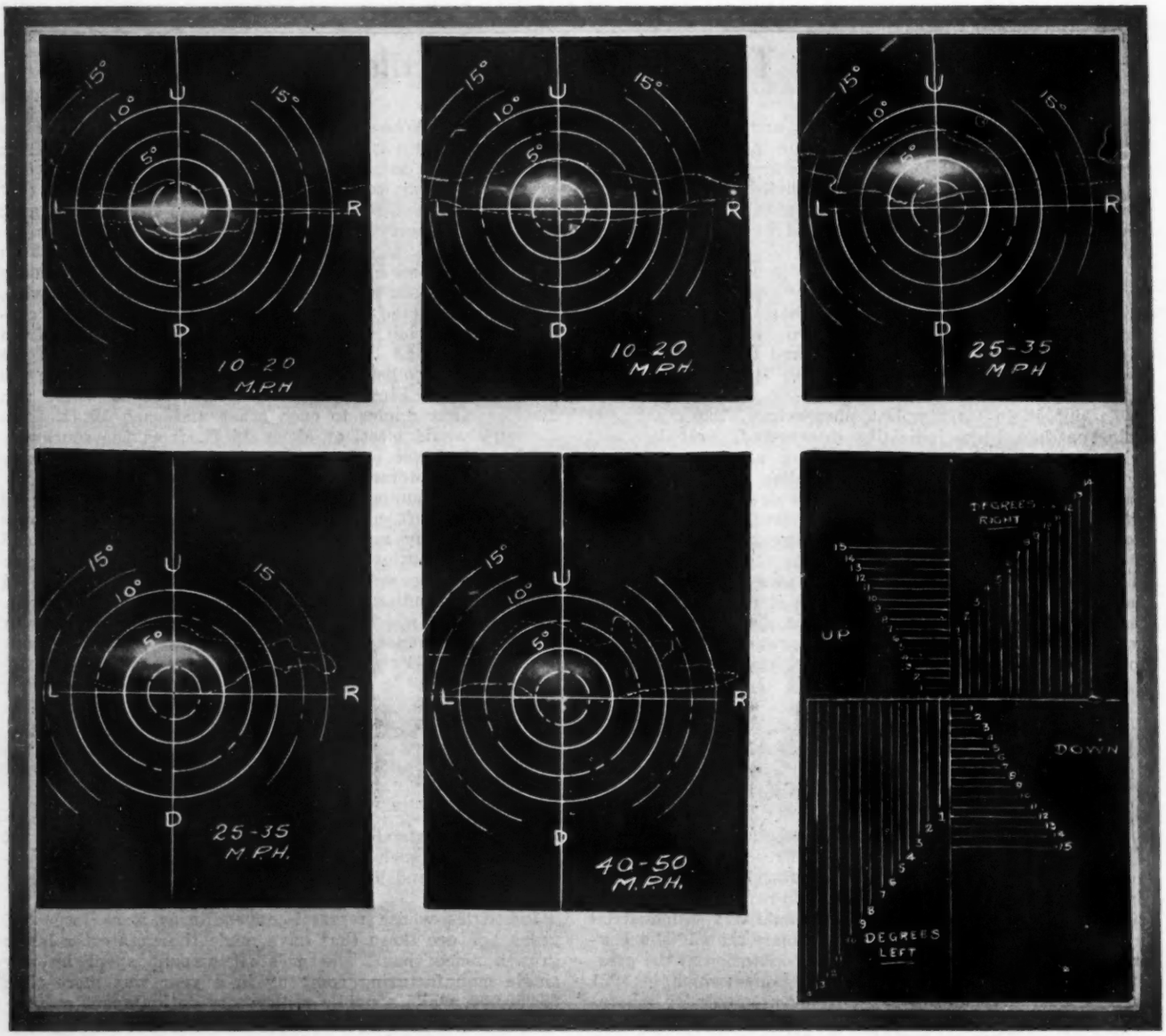


FIG. 14—SPREAD-DEMAND PHOTOGRAPHS OBTAINED AT SPEEDS OF 10 TO 45 M.P.H.
The Calibration Chart Is Shown at the Lower Right

corresponding to various angles. It was assumed that the vertical displacement on the films would be proportioned to the horizontal ones, although they may be determined in an analogous manner, by experiment.

Fig. 14 shows prints obtained from a series of runs made at speeds from 10 to 45 m.p.h. These runs lasted from 10 to 30 min. each. The results tend to show that the horizontal spread demand is in excess of 30 deg., that the vertical spread demand increases with speed and varies from about 5 deg. for speeds in the neighborhood of 15 m.p.h. to 8 or 10 deg. at 40 to 50 m.p.h. The dotted lines indicate the boundaries for the maximum areas included, and were determined by direct examination of the films. The diminishing of the brightness of the photographs as the angular displacement from the center increases indicates that the number of exposures is less. It does not follow, however, that the necessity for having illumination at these points is any less.

It should be pointed out that these photographs are not beam patterns, although their general shape is sufficiently like that of some beam patterns so that confusion might arise.

It is obvious that, if the two cars were to travel continuously in a straight line, the pattern would be a single photograph of the target at the given distance. The spread demand, under these circumstances, would be practically zero. However, at a distance of 100 ft., the car subtends an angle of about 4 deg. horizontally and vertically. Consequently, if one wishes to keep in view the whole car, not only the target, these amounts must be added to the horizontal and vertical spread demand, respectively.

Future Procedure and General Discussion

An enormous amount of work lies ahead on this project along the lines already laid down. A compilation and analysis of the collected data presents, in itself, a considerable task. The number of observations anticipated is in the thousands. However, when this is done, the testing of a considerable number of headlight equipments representative of those in use at present might be undertaken.

It has been mentioned that the head-lamp sets used in this work are those designed by the joint committee of the Society of Automotive Engineers and the Illuminating Engineering Society. In fact, three of these sets are in use at the Bureau of Standards, one of which is on a car in ordinary service.

About 20 sets of these lamps are in the hands of the engineers of a dozen different companies. These sets were designed to permit observations by a large number of engineers covering a wide variety of light patterns under actual road conditions. So far as is known, very few of these sets are in actual use, and it is to be hoped that more of them may be put in service, to the end that the accumulation of comparative data on headlighting possibilities, requirements and difficulties may be accelerated.

I am frankly of the opinion that, until the headlight problem shall have been removed from the realm of speculation, where, for the most part, it now is, and quantitative measurements under road conditions are substituted therefor, supplemented by laboratory tests based on these determinations, progress which might otherwise be hoped for will not materialize.

It is obvious that present headlighting equipment is far from ideal. Up to the present time the data have been lacking upon which to base changes in design to accomplish a more nearly ideal result. It is hoped that this project will contribute to that end by pointing out what are the most essential requirements.

Conclusions

Part 1

(1) The visibility distance under the conditions used in these tests is essentially the same for all speeds up to 40 to 50 m.p.h., other conditions remaining constant

(2) For objects of about the size of a large man, the visibility distance on a concrete road is nearly twice as great for white as for black

(3) The data tend to show a greater average visibility distance for dark nights than for moonlight nights

(4) The data show an increase in visibility distance with increase in intensity of the source, for source intensities from 2.1 to 21.0 cp. Visibility distance is roughly proportional to the cube root of the source intensity when the headlight beams are directed horizontally

(5) The effect of tilt is to decrease visibility to a very marked extent for all horizontal spreads employed, in the absence of vertically spreading lenses, this effect becoming somewhat less strikingly apparent as the horizontal spread is increased. The effect of tilt upon visibility distance decreases with increase of vertical spread, a greater increase in vertical spread being necessary to produce an equivalent per cent change with the smaller horizontal spreads than in the greater. The effect of tilt upon visibility distance from 6 to 10 deg. nominal vertical spread was practically nil for all the horizontal spreads employed

If the combination of vertical and horizontal spreads be such that an appreciable effect will be produced by either depression or elevation of the headlight beam, the effect of the former will be somewhat greater than that of the latter, particularly for tilts greater than 1½ deg. in either direction

Part 2 (*a*)

So far as a limited number of runs tends to show, the maximum spread demand at a distance of 100 ft. will be in excess of 8 deg. vertical spread and in excess of 30 deg. horizontal spread.

Agriculture in New York State

TWO-THIRDS of the area of the State of New York is in farm lands. While, among the other States, New York is only twenty-ninth in total area, and twentieth in area of land in farms, it stands eighth in the total of agricultural production. It is first in the production of potatoes, hay, sweet corn, and many vegetables. It is second in dairy products, apples, grapes, and in total value of all vegetables.

In the last 5 years the State has expended for the suppressing of bovine tuberculosis in excess of $20,000,000. This is the largest sum expended by any State in any period for this purpose; and probably the largest sum that any State has expended in the same length of time in any disease-control project.

Nearly four-fifths of the entire population of the State, or 8,500,000, reside in cities. More than 2,600,000 reside in cities other than New York City, and this is more than reside in all other parts of the State.—Alfred E. Smith.

News of Section Meetings

(*Continued from p.* 300)

of cast iron as that they contain a larger amount of metal and do not become red hot.

Drum expansion due to heating sometimes causes locking of the brakes when they have been applied continuously on long descents. Accurate measurements on a Cadillac 17-in. drum at 500 deg. fahr. showed 0.0056-in. expansion. An expansion of 0.005 in. is just enough to take up all the clearance of 0.0025 in. between the drum and the lining which was at that time given in the brakes. If the lining is a good heat conductor and the brake-band expands, the brakes can be released after the drums expand. In the case of internal brakes, expansion of the drums does not tend to cause locking, but in one make of car, in which aluminum brake-shoes were used, the shoes expanded faster than the steel drums and locked.

In conclusion, Dr. Stanley said that more complete and accurate knowledge of stopping distances will greatly increase highway efficiency, which concerns everyone, as motor-vehicles are killing more than 20,000 persons every year.

Following the presentation of the last paper was a long and animated discussion which indicated the great interest of the members and their appreciation of the importance of the subject.

UPKEEP OF MOTOR-VEHICLES

Maintenance and Servicing Features Discussed by Northern California Section

A summary of improvements suggested for motor-vehicle fleet-operation especially applicable to West Coast conditions, a description of a forthcoming text-book on the flat-rate system of service charges and methods of calculating them, and a showing of motion pictures representing the manufacturing methods applied to the new Ford car were the features presented at the meeting of the Northern California Section held Feb. 9 at the Engineers Club in San Francisco. W. S. Penfield was chairman at the technical session, which was preceded by a dinner.

Servicing City-Operated Motorcoaches

Details of the maintenance practice applied to the fleet comprising the 19 motorcoaches and 11 service trucks of the San Francisco Municipal Railroads were presented by William C. Bendel. His remarks were confined mainly to the motorcoaches, which run a total of approximately 65,000 miles per month in city service, some individual vehicles running about 5500 miles per month. On some of the routes the vehicles must stop at each street intersection during the rush period; that is, each 240 ft. The maximum speed reached is about 25 m.p.h. but, considering the stops, the schedule speed varies from say 12 m.p.h. when there are less than six stops per mile to 10 m.p.h. when there are between six and eight stops per mile. On some of the runs the vehicles are in service for 20 consecutive hours, during which time the engines are stopped once for oil and gasoline service. The fuel tanks have a capacity specified to be sufficient to run the vehicle 200 miles. The vehicles are inspected each 2000 miles.

Mr. Bendel said that when the vehicles are turned in at night they are serviced with gasoline, oil and water, and are greased. At this time service men inspect the fan belts, steering-gears, brakes, wheel bolts and tire pressures. The differentials and transmissions are inspected twice each month for proper lubrication. The engines are overhauled after an average operation of 60,000 miles; that is, the engine is removed from the chassis, tested, dismantled and reassembled. Engine cylinders are reground and new pistons, timing gears, bushings and inserted valve-seats are installed when necessary. All bearings are reamed, none being scraped; the bearing clearance maintained is 0.002 in. Connecting-rods are straightened if necessary and new piston-rings are installed about every 15,000 miles.

On the vehicles which operate over routes having the heaviest grades, air brakes are used. It has been found that it is necessary to retard these vehicles wholly with brakes, rather than to utilize the engine compression as a braking force. The reason assigned by Mr. Bendel is that drivers would use second gear and allow the vehicle to coast at a speed of say 15 to 20 m.p.h. down the 8 to 12-per cent grades, some of which are probably ¼ mile long. Engine speeds generated in this manner have been found to be as high as 3700 r.p.m. and this was found to be the cause of broken crankshafts, broken engine frames, and pistons which were forced through the ends of the cylinders.

Brake Wear Due to Severe Service

Brakes on the hilly routes are a constant source of trouble, said Mr. Bendel, due largely to the severe service that they are required to render. The compressor supplies air at a pressure of 60 lb. per sq. in., the storage reservoir being equipped with a safety valve. A brake-shoe made of 80-point-carbon steel ⅜ in. thick, operating against a brake-drum of alloy steel, has a length of life of from 1600 to 2000 miles. He said also that the average wear of the brake-drum is about ⅛ in. in say 50,000 miles; that is, a reduction of ¼ in. in diameter.

Disc wheels are used on the latest type of vehicle operated, said Mr. Bendel. The dual-tire equipment on the rear is spaced 10½ in. from rim center to rim center. Three different sizes of tire are used, 34 x 7, 36 x 8.25 and 38 x 9 in. Later practice has been to replace the 34 x 7-in. tire with 36 x 8.25-in. balloon-tires, which were said by the speaker to give a lower cost per mile, easier riding-qualities and less shock to the vehicle, due to the use of a pressure of only 55 lb. per sq. in. in the balloon tires instead of the pressure of 100 lb. per sq. in. which was used in the 34 x 7-in. tire.

Mr. Bendel then made comparisons between the wear and the service requirements of clutches on the heavy grades and on the more level routes, as well as outlining the differences in street-car-brake and motorcoach-brake maintenance.

Textbook on the Flat-Rate System

Problems relating to the compilation of a textbook which deals with methods of determining flat-rate charges for servicing were described by A. V. La Due, technical editor of *Pacific Radiator*, who said that the forthcoming work is a result of extensive surveys and is to be published in two parts, one being descriptive of short methods of performing service operations and the other consisting of details of calculation whereby the actual service charges are computed. It includes an explanation of how the rate per hour on which the charges are based was determined, details of what the procedure should be for a given operation, and estimates of the time in which a given operation should be completed.

Other Features Presented

In the absence of E. C. Wood, a summary of the important features of his report on Pacific-Coast Fleet-Maintenance Practice was read by Chairman Penfield. Since Mr. Wood's complete report was published in the January,

1928, issue of THE JOURNAL, beginning on p. 27, reference is made thereto.

The motion pictures showing the manufacturing methods applied to the new Ford car were exhibited by M. T. Kresteller, of the Kresteller Motor Co., San Francisco, who described the processes shown on the screen and provided an exhibit of Ford car parts.

The discussion following the formal features of the meeting centered largely on details of the procedure adopted by Mr. La Due to make his textbook universally applicable and upon minor details of Mr. Bendel's remarks.

AUTOMOTIVE DEVELOPMENTS REVIEWED

What's New in the Automotive Industry was the subject of the address given by A. W. Herrington at the regular monthly meeting of the Washington Section at the Racquet Club, City of Washington, the evening of Feb. 23, following a members' dinner at 6:30 p.m. Business of the Section was disposed of by the election of five members as a Nominating Committee to nominate officers for the ensuing administration year who will be voted for at the May meeting of the Section.

To the score of members in attendance Mr. Herrington told of recent changes in engines to improve their performance, of more efficient cooling systems, of clutch and transmission developments, and reviewed developments in automotive drives, axles, brakes, wheels, spring-suspension, frames, steering, and bodies.

Mr. Herrington also told of uptodate developments in motorcoaches and motor-trucks and discussed the effects of automobile racing on car design and quality. Various members participated in the ensuing discussion from 9:15 to 10:00 p.m.

Aircraft-Engine Starters

Buffalo Section Reviews Starter-Equipment Development and Discusses Present Status of Different Types

Various forms of equipment for starting aircraft engines were described and details of their suitability were discussed at the meeting of the Buffalo Section held Feb. 7. The paper was presented by J. W. Allen, chief of the electrical unit of the engineering section, materiel division of the Air Corps, Wilbur Wright Field, Fairfield, Ohio, and covered the developments of starting equipment since the war. Gustav Carvelli, of the Curtiss Aeroplane & Motor Co., Inc., was chairman, and the technical session was attended by 73 members and guests.

DEVELOPMENT OF AIRCRAFT-ENGINE STARTERS

As the size of aircraft engines increased from 200 to 400 hp., Mr. Allen said that, evidently, more power than could be applied to the propeller manually was needed to start the engine. The use of sharp-edged steel propellers also made it necessary to secure greater safety for the operator, as well as to accomplish quicker starting of the engine. Early starting equipment other than booster magnetos or coils was classified by the speaker as consisting of hand-operated turning-gears, the use of an explosive fuel-mixture, and the utilization of either a compressed-air engine or an electric motor. The requisites of satisfactory starting equipment were stated to be light weight, compactness and effectiveness.

All starters must have some form of mechanism for establishing the engagement with the engine either manually or automatically and for disengaging the starter from the engine at the time the engine starts, according to Mr. Allen. An important function of a starter is, first, to break away the engine from a condition of rest and to start it into motion under the most severe conditions, as at low temperatures when the engine oil is gummy or when the engine is new and the bearings are tight. The matter of determining the maximum torque capacity which a starter should provide is therefore difficult, since, under the foregoing conditions, the amount of torque is dependent upon the displacement of the engine, the number of cylinders, the compression ratio, and the frictional horsepower. When making an application of a starter, the engine should be rated in its proper class before the starting equipment is chosen.

Among the other functions of a starter are that it shall crank the engine against a predetermined torque at sufficient speed to start the engine; the provision of means to prevent damage to other portions of the torque transmission in case the engine should backfire or while cranking a very stiff engine, which demands the provision of mechanism either for slipping or for disconnecting the drive when the torque reaches a predetermined amount; and to provide means whereby the starter disengages itself from the engine the moment the engine starts. Mr. Allen also said that, in addition to provisions for handling each one of these features satisfactorily, the results must be obtained with a starter of minimum weight and size, since it is desirable that the starting apparatus be a unit by itself and one that can be easily assembled to the crankcase. The installation of a starter on various makes of airplane is never easy; but, the fewer projections a starter has, the easier it will be for the airplane designer to fit the engine unit, with the starter assembled to it, into the airplane.

ELECTRICALLY POWERED AND INERTIA STARTERS

Mr. Allen reviewed the functions of various equipment for starting aircraft engines. Electrically powered starters have had their greatest development in the United States. The first ones of this type used were designed for propeller-end installation, but this method developed disadvantages that led to attempts to develop a starter for a rear-end mounting which provided more positive means for meshing, an overload protective device and an accessible flange for installation purposes. Improvements were then developed which resulted in what may be termed a combined hand turning-gear and electrically powered starter.

Late in 1924, said Mr. Allen, tests made on hand-operated inertia-type starters showed that this type has the desirable characteristic of storing gradually applied energy and transmitting it to an engine quickly so as to start the engine within a short time, the principle involved being the storage of energy in a flywheel which rotates at high speed. The large amount of energy stored is expended within a time which depends upon the torque. An experimental starter was built later in which the flywheel was accelerated by an electric motor and it was found that, regardless of the starting torque of the engine, the battery capacity required per start is nearly constant. The speaker said also that the hand-operated and the electrically operated inertia starters are considered the most practical and effective.

PORTABLE STARTING EQUIPMENT

Numerous illustrations of the several types of starter were presented in lantern slides and described by Mr. Allen, including so-called "external" apparatus such as the use of "lazy tongs" or pantograph linkage mounted on a swiveled stand on the body of a motor-truck. At the end of the linkage is a standard electric starter having socket teeth on the driving shaft of the starter suitable for engaging the end of the propeller-hub bolts. The truck carries a

generator outfit for supplying power, which is driven by the engine of the truck. Another method consists in using a motorcycle equipped with a side-car which carries a large storage-battery. To start the engine of an airplane already equipped with an electrically powered starter, the motorcycle operator drives the side-car containing the storage-battery alongside the airplane and plugs its connecting wires to the electric-starter socket on the airplane, thus supplying power. The control switch is operated either from the pilot's cockpit or from the motorcycle.

Other means mentioned for powering starters include the use of a standard electric starter designed to use either 110 or 220-volt current from a power circuit, and a portable type of cranking apparatus which utilizes carbonic gas to generate the power.

Mr. Allen said in conclusion that the use of electrically operated starters, even with the attending battery weight, is felt to be not only a convenience but a need. A 12-volt battery which will give 30 or 40 starts without a recharge weighs only 36 lb., and loss of income due to displacing say 36 lb. of pay-load was said to be compensated by the shorter time required for starting.

Cost of Starters Deters Their Use

In the discussion which followed the presentation of the paper it was brought out that starters for aircraft engines are costly, which accounts in part for the fact that the so-called strong-arm method whereby the engine is started by turning the propeller manually is still in extensive use even though it is an extremely dangerous procedure. Comparing the torque required for break-away with that for rotating an engine, if a starter is operated at the usual speed, Mr. Allen said that the break-away torque is perhaps 50 lb-ft. higher than that required for rotation. He said further that a good aircraft-engine starter should be able to start an engine when the mixture is very cold and to keep the engine rotating until the mixture has been forced into the manifold continuously for the necessary period. In his belief, an air-operated starter will not do this under extreme conditions.

Remarks by Chairman Carvelli were to the effect that air-operated starters have too many joints that must be kept tight and are equipped with tanks that are too small in capacity. Another difficulty is that the pilot wastes some air while determining what amount of air supply is available and, in doing so, may not leave enough air still available to start the engine. He also said that a possible condition exists that an air-operated starter may be dangerous in case no provision is made to clean oil and gasoline from the air before it enters the tank, since this type of starter has a pump connected to the engine with which to fill the tank with air, and the air may be contaminated with oil and fuel. He mentioned an explosion of a tank which supplied the air required to inject fuel into the cylinders of a Diesel engine. The tank was 1 ft. in diameter and 3 ft. high, and its walls of cast steel were 1½ in. thick. Oil to a depth of 1 in. in the tank was found to have caused the explosion.

Design Novelties Discussed

Chicago Section Hears Fales on European and American Show Observations and Donkin on Valve Springs

Prof. D. A. Fales, of the Massachusetts Institute of Technology, and W. T. Donkin, of the Cleveland Wire Spring Co., were the speakers at the meeting of the Chicago Section, held on Feb. 14 at the rooms of the Western Society of Engineers. About 70 members and guests were present to hear Professor Fales report the new developments in automobile design and construction that he had observed at the shows in Europe and America; and Mr. Donkin's motion pictures and talk on Valve-Spring Surge.

After explaining how conditions make a European engineer more free to produce what in this Country would be called freak designs, Professor Fales said that the most interesting thing he saw in the Paris, London and Marseilles shows was the front-wheel drive, which appeared on four car models exhibited. Interesting novelties were cars designed without axles or with independent coil or rubber springs at each wheel. In some cases, each front wheel is connected independently with the steering-gear.

Engines ranging in cylinder number from 2 to 12 and in horsepower from 6 to 200 were remarked upon. The two-cycle engine is receiving attention in Europe. Superchargers, usually of the Roots blower type, are used with some of the two-cycle engines and in some of the high-speed sport-type cars. The extensive use of fabric bodies also was mentioned.

In regard to the American shows, special collapsible four and five-passenger bodies were said to be the feature of the Automobile Salon. While this type of body is not new, it has been greatly improved and may be looked for in production models in the near future. The work of artists was evident in the color schemes of the cars, both on the special bodies at the Salon and on the stock cars exhibited at the National Shows.

Tribute was paid to the American automobile manufacturer for the beauty of his cars and the remarkable value they represent. A general increase in power is noted, effected by an increase in compression pressure or cylinder displacement or engine speed. However, the engine speed has been reduced more often than it has been increased. The use of a double roller chain on one car instead of silent chain for camshaft drive was noted.

Among other developments mentioned were the decreasing road clearance of American cars, the increased use of rubber or fabric spring-mountings, the use of shatter-proof glass, and the increasing number of adjustable steering-gears and drivers' seats. Improved bumper-mountings have been provided because of serious secondary accidents that have resulted from bumpers that have become entangled in the steering wheels after a minor collision.

Professor Fales told of improvements in sleeve-valve engines in Europe. The steel sleeves used are much lighter than cast-iron sleeves, and contact between two steel surfaces is avoided by a very thin centrifugally cast lining of bearing metal inside the outer sleeve. Mention also was made of camshaft and eccentric-shaft drives from the fly-wheel end of the crankshaft, to avoid the effects of tortional vibration on the drive.

Referring to the front-drive design, Professor Fales predicted that it will eventually result in lighter and cheaper cars with reduced body height. He said that the front-drive car is safer to drive and easier to steer and that the main difficulty seems to be from the irregular action of the universal-joints during a sharp turn. Automatic transmissions and two-cycle engines are subjects of great interest also, but no radical changes can be expected in American cars within the next 2 or 3 years.

Supercharger Information Given

Some information in regard to superchargers and independent springing of the wheels was elicited during the discussion, in which Chairman Frederick G. Whittington, Lee Oldfield and O. W. Young were prominent. It was said

that tests of a Miller supercharged racing engine had shown about 200 lb. per sq. in. m.e.p. One of the Mercedes cars is fitted with a supercharger driven by double gears at the front of the crankshaft. Normally this supercharger is inactive, but it is brought into action by a clutch that is engaged when the accelerator pedal is pressed to the limit. It is said that a compression ratio of 10 to 1 was used in the Napier-Lyon engine with which the British won the Schneider Cup Race. Equal parts of gasoline and benzol were used in this engine for fuel, with the addition of ethyl fluid.

Causes of Valve-Spring Surge Discussed

Following this discussion, Mr. Donkin presented motion pictures showing valve-spring surge, saying that valve springs formerly were designed according to blueprints and specifications of the engine manufacturer, but now they are designed by spring specialists who consider the effects of the whole valve mechanism. The use of double-coil and cluster valve-springs was brought up and Mr. Donkin said that the cluster arrangement is satisfactory in airplane engines but is too expensive and too noisy for automobiles. The double coil is used in some of the more expensive automobile engines but it is difficult to design satisfactory end supports.

A puzzling cause of surge was mentioned by Don E. Williams, of the Velie Motors Corporation, on a car that had been driven about 14,000 miles in 1 year before the surge began. The trouble occurred at 45 m.p.h., at an engine speed of 2200 r.p.m. The engine had valves in the head. Several changes of head assemblies were required before the trouble was eliminated, and the valve push-rods also were changed. Mr. Donkin explained that such trouble is sometimes caused by vibration of the push-rods. A change in clearance of the push-rod adjustment also sometimes affects the vibration condition.

WILL HOLD MEETING ON MOTOR SHIP

"Met" Section Members To Dine on and Inspect Diesel-Engined Saturnia March 28

Every member of the Metropolitan Section undoubtedly will want to attend the regular monthly meeting of the Section on March 28. With considerable reluctance the Cosulich Line has given the Section permission to inspect the new Italian motor ship Saturnia, which completed her maiden transatlantic trip to New York City from Trieste on Feb. 16, bringing 1017 passengers. Members of the "Met" Section are to have possession of the vessel for the evening, dining on board, inspecting the two great Diesel engines, the officers' bridge and other features of the magnificent ship, and holding a technical session.

Considerable secrecy has surrounded the powerplant and other machinery of the new liner, which has attracted the attention of the world's marine engineers and of automotive engineers in general. The powerplant consists of two double-acting, eight-cylinder, four-cycle Diesel engines that develop 12,000 hp. each. They are 39 ft. high and 45 ft. long and drive the ship at a speed of 21 knots. The Saturnia is rated at 24,000 tons gross and 32,000 tons displacement, is 631 ft. long, 71½ ft. beam, and 91 ft. in depth from keel to flying bridge. In addition to the main engines, she has a 9000-hp. auxiliary Diesel engine that generates electricity for the lighting and other electrical equipment.

Designated by Dictator Mussolini as the "pride of the Italian marine," the Saturnia is the largest and fastest motor ship plying between the United States and Europe and is most sumptuous in accommodations and elegant in decoration.

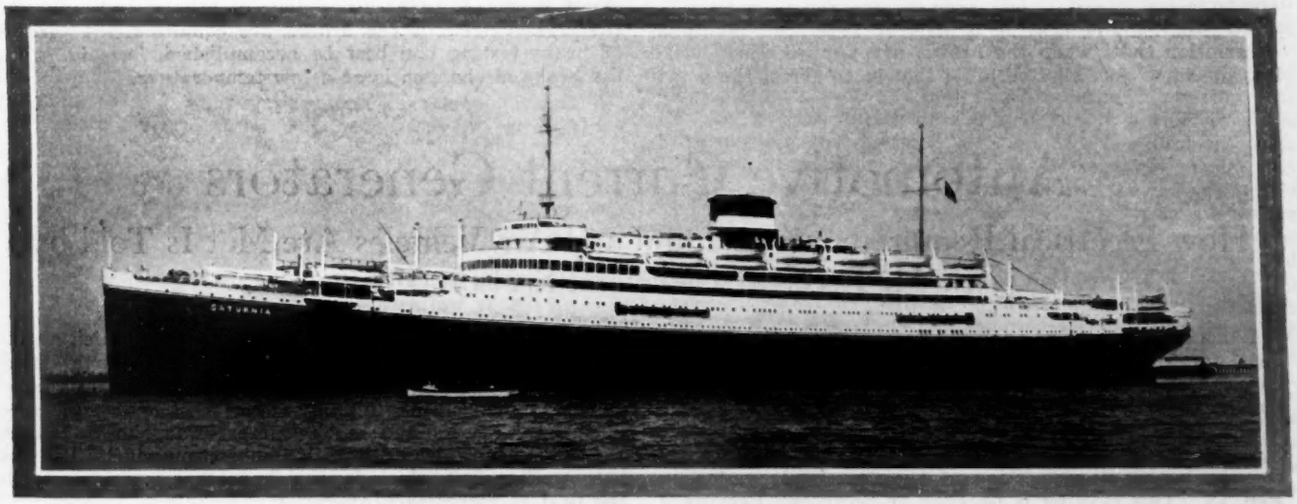
As the main dining room in which the members of the Section will have supper seats only 260 and no more can be accommodated, those who delay making reservations stand an excellent chance of having regrets instead of new information after the meeting. Two papers on Diesel engines are scheduled for the technical session following the dinner, which is to start at 6:30 p. m. One is to be by H. D. Hill, of the Hill Diesel Engine Co., of Lansing, Mich., and the other by C. L. Cummins, of the Cummins Engine Co., of Columbus, Ohio. The discussion will be led by Prof. Charles E. Lucke, of Columbia University.

Inspection of the engine room is to be made before dinner, from 5 to 6:30 p. m. A special rate of $3 for the dinner, with Italian liner cuisine and service, has been secured.

BRAKE-TESTING METHODS EXPLAINED

Equipment Pictured and Described and Improved Brake-Design Analyzed at Boston

The subject of brakes for motor-vehicles was well covered at the meeting of the New England Section held Feb. 8 at the Engineers Club, Boston. Nearly 100 members and guests were in attendance at the dinner which preceded



Metropolitan Section's Meeting Place for Its Diesel-Engine Meeting on March 28

New Cosulich Line 24,000-Hp. Italian Motor Ship Which Completed Her Maiden Voyage from Trieste to New York City on Feb. 16. Her Engine Room and Officers' Bridge Will Be Inspected by Members of the Section prior to a Dinner and a Technical Session on Board Ship at the West 44th Street Pier

the technical session, and about the same number attended the session. Frank E. H. Johnson was chairman.

A paper on brake-testing was read by Charles F. Smith, of the Brake Synchronometer Co., who described this company's type of brake-testing equipment; and a descriptive lecture illustrated by motion pictures showing the field practice used at service stations in connection with his company's testing equipment was given by F. W. Parks, of the Cowdrey Brake Tester Organization, Inc. For the benefit of readers who are especially interested in brake-testing equipment, it may be stated that a paper by Mr. Parks, entitled The Problem of Brake Adjustment, descriptive of this equipment, was presented by him at the 1927 Semi-Annual Meeting and published in THE JOURNAL for June, 1927, p. 743.

The third feature of the evening was a paper presented by H. D. Hukill, manager of the automotive brake division of the Westinghouse Air Brake Co. This paper was, however, not made available in time to include an abstract in this report.

FLYWHEEL TYPE OF EQUIPMENT

The brake synchrometer described by Mr. Smith consists of four flywheels, or rotors, mounted in bearings and capable of being engaged positively with one another and rotated in unison, or of being disengaged from one another and left free to rotate independently in accordance with such forces as may be brought to bear upon them independently. Each of the wheels of the vehicle under test rests upon a drum directly connected to one of these rotors. The flywheels are engaged with one another and the engine and the gearshift of the vehicle are operated exactly as though on the road, being speeded up until the combined mass of the four flywheels possesses the same kinetic energy that the vehicle under test possesses when operated on the road at a selected speed.

Arbitrarily, the flywheels of the brake synchrometer have been designed dynamically to be applicable to a vehicle weighing 3500 lb.; that is, in testing a vehicle of 3500-lb. weight, the rotors are run at the speed at which it is desired to test the vehicle's brakes. For heavier vehicles, the rotors are run at a slightly higher speed, and for vehicles weighing less than 3500 lb. they are run correspondingly slower; in either event the total energy of the flywheels is the same as that of the vehicle at the testing speed. When the desired speed is reached, the brakes are applied. Simultaneously and automatically the rotors are disconnected from one another and the recording instruments are set in motion, registering independently the number of feet and inches each wheel travels before it comes to rest.

Mr. Smith said that it is evident from the foregoing description that, when the brakes are applied, each brake has the same task allotted to it; that is, to arrest the movement of an independently revolving flywheel the kinetic energy of which is one-quarter that of the vehicle under test when operated on the road at the selected speed. Therefore, in arresting the rotation of the respective rotors through the medium of the respective brakes of the vehicle being tested, the functioning ability of each wheel's brake is recorded graphically. The total braking effect possessed by the vehicle undergoing test is determined from the collective results obtained from testing the brakes on all of the wheels of the vehicle. For service-station work the brake synchrometer is ordinarily provided with odometers, one for each wheel, that record in feet and fractions of feet the distance each wheel travels after the brakes are applied. For the use of brake engineers and others who require a close study of brake action, a small electrical attachment is provided that records on a tape the brake action of a vehicle.

SOME FEATURES OF THE DISCUSSION

During the discussion means whereby it is determined before brake tests and adjustments are made whether brakes are free to act were explained, and opinions as to the proportion of the total braking force which should be applied to the front wheels and to the rear wheels of four-wheel brake vehicles were expressed. It was said that differences of opinion exist as to what this proportion should be but that recently there has been a tendency toward the use of a greater braking effect on the front wheels than is provided for the rear wheels. In one instance, which was cited by Mr. Parks, the distribution of braking force is 70 per cent in the front and 30 per cent in the rear.

In reply to a question whether any tire blow-outs had occurred while brakes were being tested and whether any damage had resulted, Mr. Smith replied that there had been no such trouble but that in numerous instances defects in tires had been observed during the process of testing and that this had afforded an opportunity to obviate tire trouble by making repairs which prevented trouble.

Asked to explain how a brake-testing machine which operates at a uniform rate of speed can be used to determine deceleration at all rates of speed, Mr. Parks replied that when the brakes are applied on a vehicle the retarding force is substantially the same throughout the entire operation of stopping the vehicle, even though the rate of deceleration may vary. The speed is diminishing constantly and the retarding force is practically constant; therefore, the theory is that it makes no difference at what speed the retarding force is measured. For this reason, the brake-testing machine which he described is run at slow speed to avoid temperature rise in the brake-lining and the brake-drum. If the brakes are equalized, the process of brake testing can best be accomplished, he said, when the brake mechanism is at a low temperature.

Automotive Current Generators

How Electrical Requirements of Land and Air Vehicles Are Met Is Told by B. M. Leece at Cleveland Section Meeting

Exacting requirements for the generation of electric current for modern automotive vehicles, especially motorcoaches, airplanes and dirigibles, and how these needs are met by the manufacturers of generators, were described in a very instructive and copiously illustrated paper presented by B. M. Leece, chief engineer of the Leece-Neville Co., at the regular monthly meeting of the Cleveland Section on Feb. 13. This meeting is believed by Secretary Ferdinand Jehle, of the Section, to have been the best the Session has held this season. About 75 members and guests attended the session in the Cleveland Engineering Society's rooms at Carnegie Hall following a members' dinner at which an interesting revue was presented as a novel entertainment feature of "Old Home Week," as the meeting was designated in the announcements. Many motorcoach operators were among the guests and much interest was shown in Mr. Leece's paper, which dealt with a subject on which little has been written, yet which is very important, particularly in the field of motorcoach operation.

Prior to Mr. Leece's presentation of his paper, Chairman S. L. Bradley announced that the nominating committee had nominated candidates for next year's officers of the Section

as follows and that they would be elected by letter ballot within 60 days: Chairman, Ferdinand Jehle; vice-chairman, S. L. Bradley; secretary, E. L. Allen; treasurer, H. F. Sauer.

A. K. Brumbaugh, who was largely responsible for arranging the program of the evening, was called to the chair to preside during the delivery of the paper and through the discussion, after which Chairman Bradley resumed the chair while a reel of amateur motion pictures of the Section's outing at Nela Park last September was shown.

Heavy Demands on Electrical Source

Coincident with the development of automotive vehicles from the early days of the automobile, when electricity was used on the vehicle solely for ignition, the installation of electrical equipment has grown and greater and greater demands have been made upon generators. Requirements change rapidly with development in the powerplant and in the general design of vehicles, so that manufacturers of electric generators are constantly faced with new conditions, asserted Mr. Leece. Generators are now applied, not only to private automobiles, but to motor-trucks, motor-coaches, rail-cars, tractors, marine engines, stationary industrial engines, excavating shovels, oil-well drilling machinery, airplanes and dirigibles. Each of these applications has its own peculiarities, and nearly all require continuous service over long periods, whereas the operation of a private automobile usually is intermittent.

With the evolution of the motorcoach have come demands for head, tail, sign, marker, door, body and signal lamps, many of them of high candlepower; ignition; cooling and heating fans; heaters; pumps; and in some cases for electric refrigeration; all of which must be supplied with dependable electric energy. A high degree of reliability in constant operation is also required of the generator on the latest airplanes and airships, for ignition, engine starting, radio communication, and lighting.

Electric generators are expected today to operate under widely varying specifications as to capacity, voltage, speed, load, time and temperature, and loads are being increased despite the fact that the designers of automotive powerplants seem to overlook the point that a generator of large capacity must occupy a comparatively large space, said Mr. Leece. Under present commercial conditions, the generator capacity is often forced to the limit of material characteristics and operation is continuous; therefore, the rating of such generators is a matter of concern to both the manufacturer and the user. A demand has already arisen for 1000 and 1500-watt generators, to be driven at very low speeds.

The speaker classified modern automotive generators, in general, into four divisions:

Voltage.—Generators are used commonly with 3, 6 and 15 lead cells and correspond to the customary 6, 12 and 30-volt classifications. Some interest is also shown in 110-volt generators in automotive sizes

Current.—Capacities range from 10 to 75 amp.

Wattage.—Requirements run from 125 to 1500 watts, with no assurance that the latter figure is the maximum

Speed.—Generators have been requested which balance the battery voltage at a speed as low as 200 r.p.m., or at a vehicle speed of about 5 m.p.h. Airplanes require a balancing speed of about 2000 r.p.m.

Voltage-Regulated versus Third-Brush Types

Whereas the third-brush, or current-controlled, generator gave fairly satisfactory service on private automobiles, charging the battery at an approximately constant rate in amperes, it was found undesirable when the equipment is to be used continuously, because, when the battery becomes fully charged, the excess energy heats the electrolyte and plates. On commercial applications it is desirable to have the generator start charging the battery at a low driving-speed and to be able to continue under full load up to the maximum speed of the vehicle. Hence the voltage-regulated type was developed which supplies energy at an approximately uniform voltage and produces a charge rate automatically tapering in amperage. The characteristics of this type were shown in lantern slides of curves of performance and were compared with those of the third-brush type. Its advantages were enumerated and generators of this type were grouped by the speaker into three classes: (a) those of lower or medium capacity, in which an extremely low balancing speed is not required; (b) those of greater capacity, in which a low balancing speed is desirable; and (c) high-capacity generators for high-speed service. Various details of each of these several types or classes were described and illustrated, including those of generators for Army aircraft and for commercial airplanes.

It is not to be assumed, said Mr. Leece in conclusion, that the present voltage-regulated systems are the ultimate to be achieved; experimental work is going on continuously to improve the performance, simplify the apparatus, and extend its applications. The electrical equipment manufacturer, however, needs cooperation from the engine builder, who should realize that the generator equipment must occupy space adequate to the service demanded of it and that proper driving speeds and means and better mounting arrangements should be provided.

Why Operators and Makers Have Trouble

Prolonged discussion of the subject by motorcoach operators, on the one hand, and motorcoach builders and generator manufacturers, on the other hand, showed with clarity that many of the troubles which operators have with the electrical equipment are due to installation of supplemental lights, fans, higher-power lamps, and other equipment which require more current than the generator is designed to deliver; also to the operation of motorcoaches in services requiring frequent stops with short intermediate runs, or to a combination urban service, calling for slow speed and numerous stops, and suburban or interurban service, calling for high speed with few stops. When the current source fails to meet the extra demands, the equipment maker is called upon to remedy the trouble.

According to one operator, the generator maker, in one specific case, claimed his apparatus was all right but that the battery was wrong; the battery man said the battery was all right but the body was wired wrong, and the body maker asserted that the body was all right. Finally, the operator checked up and found that the motorcoach was using a 42-amp. discharge with a 25-amp. generator. As a preventive of such troubles, he believes that if the electrical engineers of the chassis, body and generator makers would get together they could solve the electrical problem of the operator.

Mr. Leece said that he knew the motorcoach referred to; that the generator was designed for normal operating conditions but the vehicle was put on a school run on which the average speed was 8 or 9 m.p.h. The problem is to provide a generator, he said, that is variable enough and flexible enough to supply current when the motorcoach is run at 50 m.h.p. in some other service. Space allotments for the generator do not permit of designing a generator that will operate at full capacity at 600 to 700 r.p.m. and that will also commutate at 3500 to 4000 r.p.m. Unless the engine makers will provide adequate space for a generator that will operate over this speed range, the operators are out of luck.

Large Equipment Economical but Needs Space

C. T. Klug, of the Willard Storage Battery Co., agreed with Mr. Leece and said that ample voltage equipment gives longer battery life and in the long run a large battery gives the operator the lowest cost per mile in the equipment, particularly in any installation that is run continuously. His investigation shows that loads on the electrical equipment are constantly becoming heavier. He said that electric heating of motorcoaches is in the offing and he expects soon

to see motorcoaches equipped with electric refrigerators so the passengers can ice their drinks.

A. J. Scaife, of the White Motor Co., remarked that if the vehicle builder is to put on the motorcoach all the apparatus the operators want the engine will have to be moved to one side to make room for the generator and the generator put in the bottom. "By the time we get through we won't have any power."

Asked by Ferdinand Jehle, of the White Motor Co., whether a smaller battery suffices for a voltage-controlled generator than for a third-brush generator, and for definite information as to the sizes of battery required for 300, 400 and 500-watt generators, Mr. Leece stated that some work is at present being done in committees on this subject. Size of the battery for voltage-regulated generators is determined primarily by the amount of time the vehicle is operated below the effective charging speed of the generator. The size of the battery does not matter, however, except that the charge rate must be regulated to the maximum capacity of the generator rather than that of the battery.

Automatic Production of Chassis Frames

Detroit Section Sees Motion Pictures and Hears about A. O. Smith Frame-Building Process—Body Division Launched

Vaudeville of the highest order accompanied the dinner at the Detroit Section Meeting held in the Book-Cadillac Hotel on the evening of Feb. 13. It was called a "radio artist" program, as it was arranged by E. W. Austin with the help of Bob Sheehan, who is a radio artist, and included an orchestra and other radio performers. However, the dances of "Babe" Morris and Betty Bell have not yet been broadcast by radio. Cheering members and guests to the number of 340 attended the dinner and about 125 more attended the meeting which followed.

During the preliminaries of the technical session, Chairman Walter T. Fishleigh announced the report of the Nominating Committee, which proposed the names of the following men as officers for the 1928-1929 term: B. J. Lemon, chairman; L. Clayton Hill, vice-chairman; L. A. Chaminade, secretary; and F. W. Marschner, treasurer. The chairman also announced that Mr. Hill had taken over the work of editing the *Super-Charger* since the departure from Detroit of E. V. Rippingille. Mr. Marschner already has succeeded Mr. Rippingille as treasurer.

For some time there have been reports of the wonderful automatic plant of the A. O. Smith Corporation, in Milwaukee, for building automobile frames, but no description of the plant has ever been made public. This is said to be the greatest automatic machine at work in the automotive industry, receiving and inspecting strip steel and turning it out in the form of completed and enameled automobile frames without their being touched by human hands, the work and handling being entirely automatic.

At this meeting John P. Kelley showed motion pictures depicting the plant in operation and described the process in detail. A. W. Redland, general manager of the frame plant, also was present to answer questions. Some of the pictures taken several years ago were supplemented by new films taken the week before the meeting to show improvements that had been made in the processes.

Inspecting and Piling Stock

Strip steel is used in this plant as frame material. When it is received it is passed between rollers to correct any curvature and then goes through an automatic inspection machine which measures the strips for length, width, thickness and curvature. Any strip that is outside the inspection limits is automatically lifted by magnets and rejected. This machine inspects and piles 900 strips per hr. After inspection, the strips are pickled, washed, neutralized and oiled before being transferred to the manufacturing lines.

In the side-member manufacturing line are six presses driven by a single 500-hp. motor. The strips go down this line in pairs on carriages. The sequence of operations is: (*a*) offsetting strips for vertical bends in the frame, (*b*) piercing left-hand strips, (*c*) piercing right-hand strips, (*d*) blanking both sides, (*e*) forming left-hand blanks, and (*f*) forming right-hand blanks.

In the cross-member unit are four lines which include a small riveting press for the completion of cross-member sub-assemblies. Another line carries the pairs of side-members through 19 stations, at each of which several machines are operated, to complete the side-member sub-assemblies by pinning and riveting the brackets in place.

In the general assembly line, the machine picks up side-member and cross-member sub-assemblies, clamps them together and drives and heads the rivets, all automatically. A conveyor then carries the frames to the final inspection line, where they are checked by inspectors, after which the completed frames are washed, dried and given a coat of baking enamel.

Frames Made in Less Than 2 Hr.

Fabrication of a frame requires 40 min. after the steel is pickled and 1 hr. more for the cleaning, enameling and baking, or about 1 hr. and 50 min. from the raw material until the complete frame assembly is ready to ship.

This plant is run with three shifts of men through 7 days without a stop except for 6 min. each morning and night. To change the tools for production of one type of frame to those for another requires 10 hr. of work by 200 workmen. Mr. Kelley said that the company expects to reduce the change-over time to 8 hr.

It is hoped that it will be possible to secure "still" photographs and to present Mr. Kelley's paper in full in The Journal.

One feature of the evening was the attendance of a large group of members of the student branch that is being organized at Detroit University, with about 400 members. Prof. John J. Caton, who is mainly responsible for its organization, spoke briefly for the students. Announcements were made by Chairman Fishleigh and Meetings Committee Chairman Walter C. Keyes that at the March 5 meeting of the Section a representative of the Westinghouse Company will tell about the new drive for automobiles that has been developed that will eliminate gear-shifting. Ferdinand Jehle will be the speaker on April 2, and May 7 will be Ladies' Night, for which a very popular speaker has been invited.

Organization of Body Division

As previously announced, a meeting of Detroit Section members who are interested in body designing and production was called at the close of the regular Section meeting. In opening the body meeting, Chairman Fishleigh made it very plain that the success of a body division would depend entirely upon the enthusiasm and work contributed by the body men themselves.

The project had been under consideration for some time to hold additional meetings of the Detroit Section on body subjects, and it now has received the approval of the Council of the Society. The plan is to have a vice-chairman of the Section representing body engineering who shall preside at the body sessions; also a special subcommittee on body meetings, the chairman of which shall be a member of the

Meetings Committee of the Section. The vice-chairman is to be a member of the Governing Committee.

Much enthusiasm was shown and the members expressed confidence and determination that the Body Division would be a success, as it will meet a need that exists for greater activity in regard to body subjects, to which a large amount of time cannot be given in the regular meetings of the Section.

William M. Davis, body engineer of the Cadillac Motor Car Co., was nominated as Body-Division Vice-Chairman of the Section, and C. B. Parsons as chairman of the Body-Division Meetings Committee. It was voted to hold two meetings of the body division during the current season, on the third Mondays of March and April. A number of topics for meetings were suggested for the consideration of the meetings committee, among them the following: obstruction to vision; reflections from the glass; steel versus composite doors; body ventilation; high-speed roars and body rumbles; elimination of body sills; body anchorage with four-wheel brakes; application of rubber in body construction; relation of chassis frame design to body construction; visor design and construction; welding methods; seat design; adjustable driver's seat; body finishing; and accessibility of chassis units through the body.

Specialized versus General Maintenance

Metropolitan Section Analyzes Both Kinds of Service-Station Work—Car Dealers Criticized for Indifference

Engine reconditioning, oxy-acetylene welding, specialized service "down the street," and brake-testing equipment, compelled the interest of 275 members and guests at the meeting of the Metropolitan Section held in cooperation with the Automotive Service Association at the Building Trades Club in New York City on Feb. 16, and 225 attended the dinner which preceded it. E. F. Lowe, chairman of the Section, delegated the chairmanship of the technical session to H. R. Cobleigh, secretary of service for the National Automobile Chamber of Commerce, who then officiated as chairman and introduced the speakers. In addition to members of the Society, among the audience were representatives of the Automotive Service Association, the Motor Truck Association, the Motor Truck Maintenance Club, the motor-transport division of the American Railway Association, and the New York Railroad Club.

The papers presented were by Dwight W. Grover, president of the Motor Craft Corporation and past-president of the National Motor Grinders & Rebuilders Association, on the subject of engine reconditioning; by Charles Michaels, of Michaels & Mourre, Inc., on Welding as a Specialized Service; by F. L. Oberheu, of the United Motors Service, Inc., entitled Specialized Service "Down the Street"; and by F. W. Parks, vice-president of the Cowdrey Brake Tester Corporation, Inc., on Brake Testing and Adjustment.

Importance of Engine Reconditioning

Engine reconditioning was classed by Mr. Grover as being the most important item of automotive maintenance. Since the public is demanding more definite and efficient service, he said that the business of the future will go to the shops having the proper equipment, skilled mechanics and the ability to predetermine costs. The reconditioning of engines successfully is a specialized branch of maintenance which must be done in shops equipped with heavy-duty machinery such as is used by the car builders, where a complete stock of parts is available, and which employ highly specialized machinists for the machining work and skilled engine mechanics for the engine work. Adequate equipment, in the speaker's opinion, should include cylinder-grinding machines and grinders for pistons and crankshafts, equipment for rebabbitting connecting-rods, boring machines for main bearings and connecting-rods, testing stands for engines, lathes, drilling, milling and planing machines, and various small hand tools, together with a complete assortment of fine instruments for making precision measurements.

In conclusion, Mr. Grover said that not only is this the day of specialization but it is also the day of mergers and consolidation. His vision of convenient and economic maintenance is in grouping the specialists, housing them in specially designed buildings prominently located, where the car owner can obtain in one establishment all the items of maintenance at the right price and with reasonable promptness. If properly operated, said Mr. Grover, such an organization can secure also the service business of many motor-car agencies which now maintain service departments at a loss and which really prefer to devote their entire time to selling motor-vehicles.

Welding as a Specialized Service

Mr. Michaels said in part that his remarks were confined to welding as a specialized service applicable in both authorized service-stations and the service stations of privately owned fleets of motorcoaches, taxicabs and motor-trucks in the Metropolitan District of New York City only. In reference to his understanding of the term "welding," he said that he refers to the oxy-acetylene method, as the use of the electric arc for welding in the service stations referred to is practically nil. One reason for this is that the electric-arc welding-equipment is much more costly than the oxy-acetylene equipment.

Objections to the use of the welding torch in a service station were cited by Mr. Michaels as being that (*a*) welding is rated by the insurance companies as an extra-hazardous occupation, that is, it increases the workmen's compensation and fire-insurance premiums; (*b*) the Bureau of Combustibles of New York City has prescribed that welding of this character must be done in a room especially used for this purpose and separated from the remainder of the shop by an 8-in. brick wall with self-closing approved fireproof doors, other requirements being that the welder have a permit which must be renewed yearly and that the owner also must have a permit for the storage of compressed gases, such as acetylene and oxygen; and (*c*) a welding job is only as good as is the capability of the welder to execute good welding work.

In contrast, the speaker said that there is no scarcity of centrally located shops which specialize in welding work and which can do the best possible work at a price which competition has made very reasonable. He then presented an analysis of the cost of operation of a welding department in a service station as compared with the cost of having welding done by specialists. In conclusion, he advised that any service stations in which a welding department is maintained keep a separate account of all welding work which will constitute a complete cost analysis of all the welding work done.

Dealers Drove Service "Down the Street"

It was the prediction of Mr. Oberheu that the builders of motor-cars and the car dealers will play only a minor part in the actual service repair work of the future. He said that, in the final analysis, the leveling-out process in any

industry depends upon how lazy or indifferent one side is and how alive and aggressive the other side may be. In analyzing whether the motor-car builders and dealers have been awake to service possibilities to date, he mentioned that they were responsible for creating the need for gasoline and oil service yet they drove away from their doors the tremendous business of gasoline and oil supplying and sent it "down the street." The car dealers, he said, had first option on the tire business and on battery work and, likewise, they sent it "down the street." The same process was true also in the case of the accessories business and the parts-supply business. This last gave rise to the parts house, which was made possible on the following basis:

(1) Car dealers would not sell parts to one another at fair prices to use on cars traded in, and this practice is still generally true

(2) The car dealer became immediately the largest and best customer of the parts house

(3) Selling cars kept the car dealer busy and the car builder was scarcely conscious of the possibilities of the parts business

(4) The car builder was ignorant of the development of service stations and did not realize the repairman's need for parts

(5) Car builders and car dealers refused to quote proper prices or would not recognize the independent repairman's right to a place in the industry

(6) The car builders failed to provide general catalog and service information

With this gross neglect and indifference on the part of the car builders and car dealers, Mr. Oberheu asked what more a parts house could ask for to make its venture a success. The equipment manufacturers who supplied parts stores studied the service business. Catalogs, manuals, fair list-prices, and reasonable discounts were given to the independent or specialized service-station operators. The parts store was glad to sell to all classes of the trade.

Mr. Oberheu said also that a specialized service-station making a close study of a particular type of service work naturally can build up a better-balanced parts stock to do the work. A specialist in radiator work, electrical work, speedometer work, or any other branch of service work can find short-cut methods of locating the seat of the trouble and work out ingenious methods of repairing various units. The car dealer or the manager of any other general repair shop who cannot possibly have men specializing on *each* type of service work will oftentimes revert to a freer use of repair parts with a resultant higher cost of service to the car owner. Selling complete radiators where repairs or flushing the old one might have sufficed, or using coils and new armatures where minor repairs might have saved the old parts, only serves to emphasize the advantages of specialized service over having work done by general mechanics attempting to do a little of everything.

In conclusion, Mr. Oberheu said that there will be an ever-increasing need for specialized service. People become more critical of their service requirements; they demand personal service. The actual service transaction always will be a deal between two persons.

Brake-Testing Equipment Illustrated

A descriptive lecture illustrated by motion pictures showing the field practice used at service stations in connection with his company's brake-testing equipment was given by Mr. Parks. A paper by Mr. Parks, entitled The Problem of Brake Adjustment, descriptive of this brake-testing equipment, was presented by him at the 1927 Semi-Annual Meeting and published in THE JOURNAL for June, 1927, p. 743.

During the course of the discussion it was said by L. T. Hanford, service director for the Dalley-Jennings-Graham Corporation, New York City, that, as a representative of a car dealer, he favors specialized service and believes that certain specialized services have arisen because they are normal eventualities which developed on the basis of convenience. It was just as eventual that specialized service would develop as is the fact that cars are now being equipped with many accessories which dealers and jobbers in accessories have been selling. In his opinion the specialized service fills a need in that it can perform for the authorized service-station those repairs which, because of their frequency, do not warrant the equipment that the service station would need to have to perform such work efficiently and to take care of those repairs which, because of their peculiar nature, require experts who continually are doing that kind of work. As a representative of a car-dealer's service-station, Mr. Hanford said that he is glad the auxiliary service-stations exist and he believes that the authorized service-station still has its appeal to the car owner and will continue.

Dealer Should Be Maintenance Clearing-House

With regard to further improvement of servicing, it was brought out by H. R. Cobleigh that it seems certain that more and more of the principles and practices that have been applied in the production field to make new vehicles as reasonable in cost as they are today will be adopted. A fundamental of this accomplishment, said Mr. Cobleigh, is that there be a large volume of service business, which cannot be obtained in the service stations existent in the small towns. He asked what will happen to the dealer if specialization in service goes much further. In one sense, he said, we are not interested in the dealer so far as he himself is concerned, but we are mightily concerned about the industry and the owner. He remarked further that the dealer is a necessity to the industry, and that it is decidedly to the interest of the owner that the dealer continue in business. For this reason, apparently, it will be necessary for the dealer's salvation that there be some revenue for maintenance, and it seems to Mr. Cobleigh that the dealer can well justify himself as a clearing-house for maintenance for the owner. If the dealer serves a useful function to that extent, saving the owner the necessity of going from place to place to get his service work done, the dealer is entitled to a reward in the nature of a commission.

Science and Happiness

MEN of science, who have less difficulty than any others in finding an outlet for creativeness, are the happiest of intelligent men in the modern world, since their creative ability affords full satisfaction to mind and spirit as well as to the instinct of creation. In them a beginning is to be seen of the new way of life which is to be sought; in their happiness we may perhaps find the germ of a future happiness for all mankind.—Bertrand Russel.

Standardization Activities

(*Continued from p.* 324)

led to believe it is. Cannot the automobile manufacturers, who should know what oil an engine should use, simply stipulate the viscosity of the oil for that engine and give the other qualities which are necessary for the desired grade of oil?

It seems to me that the viscosity number defines the oil by only one characteristic that is just as inadequate as to define the quality and usefulness of a car by stipulating the design of the body or the kind of brakes or the size of the engine. We oil manufacturers do not want to sell oil that way. Some of the other important characteristics which define the suitability and quality of the oil should be specified. Speaking for my company, I think it would be willing to use an oil number if it did not have "S.A.E." in front of it.

VICE-CHAIRMAN SCAIFE:—The trouble with that idea is that one company's numbers will not correspond with another company's numbers, without some definite standard as the basis. My first thought was to use the numbers without the S.A.E. but this is liable to lead into a lot of things. For one thing, it would be no protection against the "gyp." He could call his oil No. 30 or No. 20 or could call it light, medium or heavy.

MR. GRIMES:—I have been impressed by the ideas of Mr. Danse, of the Cadillac Motor Car Co., who was among the first to lay a great deal of stress upon the volatility of oils. If the viscosity and the volatility, and perhaps the fire and flash, could be given, it would be a good way to define almost any oil.

FILLER STATIONS IGNORANT OF TRUCK REQUIREMENTS

J. B. FISHER, Waukesha Motor Co.:—Heavy industrial engines suffer especially from the use of too light or too heavy an oil. This occurs through the ignorance of the average man in the filling-station. A passenger-car operates on a very light load-factor but the industrial engine is very likely to be operating on 80 or 90 per cent of full load. Imagine this scene taking place at the average filling-station: A car drives up and the attendant puts in oil of a certain viscosity which he has found functions all right in that engine. Right back of the automobile a 5-ton truck carrying a 5-ton load drives up for oil. The engine seems about the same size as the engine in the automobile. The attendant puts in an oil of about the same viscosity, with the result that it will be entirely too light an oil for operating that engine.

We have suffered severely from the ignorance of the man in the filling-station who puts too light an oil in heavy-duty engines. Another fact to remember is that, with the use of seven bearings and larger crankshafts, the oil temperatures in the crankcase are considerably higher than they were with the three-bearing engines a few years ago. This is a further argument for being able to tell the operator to use an oil of the correct viscosity, especially in heavy-duty service.

I do not think that an S.A.E. Number will designate the quality of an oil any more than the S.A.E. Ball-Bearing Numbers define the capacity of ball bearings. It is more important to see that the operator uses oil of the right viscosity than to leave him in the dark on the points that have been brought up by some of the oil men.

REACTION OF OIL-MANUFACTURING DIVISION

SYDNEY BEVIN, Tide Water Oil Co.:—This question of the S.A.E. Viscosity-Numbers has been discussed for some time and the refiners have had several years to contemplate what it means to them. The sales departments in most of the oil companies first shied away from the idea for the reasons Mr. Round brought up. Many of them feel that there is not a great advantage in it.

A point that has not been touched on at all is the reaction of the manufacturing end of the oil business to the S.A.E. Viscosity-Number system. When the manufacturing division in my company was first approached, it asked if this was another group of specifications to which it would have to make oils. It said then that it would not cooperate unless the S.A.E. Numbers and the specifications they then represented would hold for 5 or 6 years. When the numbers were made to designate viscosities only, their reaction was to cooperate.

MR. ROUND:—None of us is in any doubt as to the meaning of the S.A.E. Viscosity-Numbers, but the layman does not knew their limitations and the placing of the numbers on the filler pipe would logically lead him to think that all oils bearing the same number are equal in quality. Would it be reasonable to expect an oil salesman to tell him otherwise or to fail to imply S.A.E. endorsement if he thought he could gain by it? We have proof that in some instances this is what the salesmen are being instructed to do.

VICE-CHAIRMAN SCAIFE:—What interests me is that the companies that have been using the numbers see a decided advantage in them but the companies that have not feel otherwise about them.

BEST SYSTEM SUGGESTED FOR RECOMMENDING OILS

H. C. MOUGEY, General Motors Corporation Research Laboratories:—I believe Mr. Upham has covered the matter thoroughly. The automobile companies need some system by which they can recommend oils for use in their cars. The present system was given to the Society by the oil men of the American Society for Testing Materials and has been adopted by the Society long enough for everybody to be thoroughly familiar with it. It is the best system that has been suggested for the automobile companies to use in recommending oil to the car owners. I should like to have anyone who is objecting to the system suggest any better way.

MR. CLARK:—Mr. Round and I are not objecting to the use of viscosity numbers; viscosity is one of the most important characteristics to be specified. What we object to is using the name of the Society on a viscosity specification, which will be misused by the general public. Each year, after an exhaustive study of each car, our engineers issue a chart with specifications for the grades of oil as to viscosity and other properties which are necessary to define the quality of oil for any given service. All other reputable oil companies do the same. That is all the public needs, together with confidence that the people selling the oils know what they are selling and what it will do in their cars.

H. J. SALADIN, Standard Oil Co. of Indiana:—We have come to the conclusion, after careful consideration, that the oil people owe it to the automobile industry to give them some method of designating viscosity for the light, medium, heavy and super-efficient grades of oil. The automotive manufacturer has no means at present of designating the body of an oil that will give him any assurance that he is going to get the kind of oil he wants. The Society has attempted, with the cooperation of many oil men in the American Society for Testing Materials, to offer such a means. We realize that there is danger of the S.A.E. Viscosity-Numbers being misused, and suggest that the automobile manufacturer indicate in no uncertain way that the numbers do not refer to quality, but only to the body, which is now termed light, medium or heavy. If this precaution were taken, a large part of the danger of the

"gyp" could be eliminated. Our company expects in the near future to issue its oils under S.A.E. Viscosity-Numbers because we think it is the best way the automobile companies have at this time for designating oils.

F. W. SAMPSON, Continental Motor Corporation:—All of the oil companies must not be very friendly, else they would have established a standard long ago and we should not need to have an S.A.E. Specification. A large part of my time in the last month or so has been used in filling out questionnaires of the various companies so that they can make some sort of recommendation. I would say this is a matter either of accepting what the Society has to offer or of the oil companies getting busy quickly and drawing up a standard of their own to safeguard themselves.

SMALL OIL COMPANY WOULD CAPITALIZE SYSTEM

MR. ROUND:—There is a representative here from a Western oil company who is not a member of the Society. I should like to have him tell what he told me.

A. W. GUTTERSON, Wilhelmina Oil Co.:—As the owner of one of the small companies operating in a few States and not doing National advertising, I would say that, if the S.A.E. Viscosity designation is adopted, the only course open to me is to put it on my cans, and if the big oil companies do it, I shall have to instruct my salesmen to go out and capitalize on it. It seems to me that in adopting S.A.E. Numbers, in view of the opposition to a viscosity designation, you are helping to destroy the personality that the larger oil companies have built up around their goods.

We in the country are in closer contact perhaps with the user. Were only one S.A.E. Number specified for a given car without regard to condition of the engine or type of service, it would be more embarrassing for us than it is now in seeking, by using a heavier oil under certain conditions, to fit the operating conditions which our oil encounters.

It is not fair to speak of the smaller oil companies that would capitalize on the S.A.E. designation as "gyp" companies, because they could not reasonably do anything else than point with pride to the same specification on their cans, when the buyer asks whether their oils meet the specifications, that the large oil companies have on their cans.

General adoption of the S.A.E. Numbers by car manufacturers will undoubtedly be a hardship temporarily on the manufacturers of certain expensive, Nationally advertised brands of oil, but I believe there is urgent need of some definite form of viscosity specification for use by the car manufacturers.

VICE-CHAIRMAN SCAIFE:—If the small company's oil has the same characteristics as are required of other oils, that is all that interests the Society, or the engineers, so far as quality is concerned. If it has not the same characteristics, that is another matter.

This subject is not before us now for adoption, as it was disposed of more than a year ago. The discussion is for a little publicity to see if the system cannot be used generally. As was said by Mr. Mougey, if there is a better method, let us have it.

TRIAL ALONE WILL PROVE THE SYSTEM

A. LUDLOW CLAYDEN, Sun Oil Co.:—The placing of S.A.E. Viscosity-Numbers on engine filler-pipes is one of those things the effectiveness of which can be settled only by trial. The desire of automobile manufacturers to ensure the use of approximately correct-viscosity oil is entirely logical and is so considered by all refiners.

It would be possible to discuss at considerable length the present method of listing S.A.E. viscosities. For instance, it is possible for certain of the grades to overlap. Better results might be obtained by choosing different temperatures for the viscosity ratings, but no change of this kind ought to affect the numbering system.

We have a series of numbers; S.A.E. No. 30 means an oil varying in viscosity within certain limits. If it is found in practice that these limits are either too wide or not wide enough, it will be necessary to change the method of specifying the viscosity which S.A.E. No. 30 represents. Nothing prevents changing the meaning of the numbers, and there should be no future necessity to change the numbers themselves. A similar situation is seen in other industries. For instance, some alloys produced by certain companies have borne the same serial-number for years although the precise composition of the alloys has changed from time to time.

It is probable that the present method of specifying the S.A.E. viscosities at the higher end of the series will not prove satisfactory. Should this be the case, the numbers can be left unchanged; it will only be necessary to alter the method of specifying the viscosities to which those numbers refer.

The extent to which the viscosity numbers shall be used depends almost entirely upon the automobile industry. If sufficient insistence is put upon their use by distributers and dealers, so that the car owner will become familiar with the numbers, I think their use will grow very fast, but, lacking such pressure, progress will probably be extremely slow.

STEEL CHARTS TO BE CONTINUED

Proposal under Consideration by Iron and Steel Division Discussed

One of the purposes in discussing the changes proposed in the physical-property charts of the S.A.E. Steels or possibly the advisability of discontinuing them entirely was to give members of the Society and others the opportunity to discuss the subject directly with H. T. Chandler, chairman of the Subdivision, and with the Iron and Steel Division. At the Standards Committee Meeting in Detroit last January it was felt that, with the importance of these charts, particularly to small users of steels, and because of the limited number of replies to Division correspondence on the subject, it would be a valuable aid in continuing the work to present it for open discussion. Mr. Chandler's paper and the discussion thereof follow:

CHARTS NOT TO BE CHANGED SUBSTANTIALLY

H. T. CHANDLER, Vanadium Corporation of America:—The title of this discussion may be considered misleading inasmuch as the Subdivision of the Iron and Steel Division that has been working on the charts of physical properties for S.A.E. Steels has no serious intention of eliminating them from the S.A.E. HANDBOOK. Following Mr. Janitzky's paper at the Society's Production Meeting in Detroit, last fall, there was considerable discussion and correspondence which indicated a feeling on the part of some of the members that serious changes in the charts were contemplated which would be confusing and possibly less informing to engineers accustomed to the ones now published. As a matter of fact, the charts are not to be changed substantially in form. What the Division has in mind is rather a change in the methods of obtaining the data from which the charts are constructed, with the object of presenting more accurately to the engineer the properties and characteristics of the different steels.

Whereas in the present charts the results were obtained from laboratory action and therefore are subject to many obvious limitations, the data for the new charts will represent the collective experience of *actual use*, and will more truly indicate what may be expected from the steels in commercial practice.

The Division expects to gather from every source available as many results as possible of tests on the various steels under consideration. These data will then be subjected to the mathematical treatment discussed in Mr. Janitzky's paper, following the general rules of the mathematics of probability. The theory of probability is merely a math-

ematical statement of the fact that we can predict, more or less accurately, what will happen in the future from observations of what has occurred in the past. The accuracy of the prediction is determined by the number of observations. The figures so obtained will be plotted as the characteristics of the steel and will thus be accurate graphs, based on experience, of what may be expected from the steel. This method is by no means a new or untried procedure; it is the standard and accepted method of digesting data in other branches of physical measurement in which the number of variables influencing the results is large and their effects complicated.

A Limitation of Present Charts Overcome

One limitation of the present charts arises from the fact that the individual steel specifications, because of necessary commercial chemical variations, do not sharply define any single definite steel but rather indicate a series of steels, all similar but nevertheless differing considerably in their physical characteristics within the permitted range of analysis, treatment, size and so forth. Thus, in a particular specification which covers a range of 10 points in carbon, 20 points in manganese, and corresponding ranges in the other elements of composition, there can occur many combinations of different values of the respective elements, each combination defining a different steel and hence yielding different results in test after the same treatment. In addition, variations in results are also introduced through changes in size, temperature, source of material, skill of labor, and so forth. Thus, within the limits of a given specification of analysis and process, a wide range of properties is possible.

Which set of properties then can be used as being representative of the steel defined by the specification?

The engineer's chief interest lies in knowing the minimum combination of strength and toughness he is likely to obtain under the conditions covered by the specifications.

With these facts in mind, the procedure of the subdivisions which have prepared the present charts has been to determine the minimum strength possible within the chemical limits of the specification as indicated by elastic limit and tensile strength, as well as the minimum toughness as expressed by elongation and reduction in area. This was done by testing in the laboratory, a series of selected bars representing the high and low limits of the specified range of chemical composition. The minimum elastic limit and tensile strength as well as the minimum elongation and reduction of area were then plotted as characteristics of the steel.

For the metallurgist who is familiar with the effects of the different elements on the physical characteristics of steel, and thereby is capable of judging their quantitative influence under variable commercial conditions, such charts, properly interpreted, give a fair estimate of what can be expected from the specification. For the engineer, however, who must accept the charts at their face value without allowances for differences arising in practice or differences in sensitivity of steel to process and heat-treatment, results plotted as above are not sufficient and may be misleading.

One reason for this is that an inverse relation exists in any given steel between its toughness and strength. Most of the factors, such as heat-treatment, size and the effect of alloys, which tend to produce an increase in strength operate generally at the same time to decrease the toughness. The converse also is true.

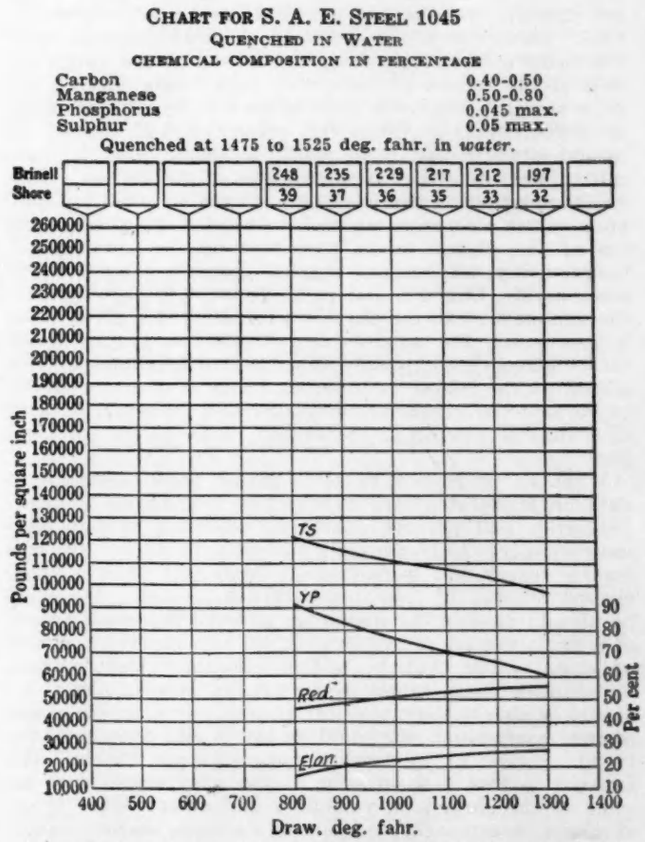
Minimum strength and minimum toughness therefore seldom if ever occur simultaneously. Actually the lower the elastic limit is, the higher the elongation will be. The same is true of the tensile strength and the reduction in area. These properties are not independent of each other in any given steel, and we cannot, therefore, interpret the plottings as being independent functions. It is seldom useful to the engineer to consider strength without at the same time considering the toughness associated with that strength, nor to consider toughness by itself without its accompanying strength. Charts constructed by using the minimum values of interrelated variable quantities indicate a set of conditions which actually does not exist, and their correct interpretation presupposes a complete knowledge of the conditions under which they were made, as well as the effects of changes in those conditions. Such knowledge is properly that of the metallurgist but is not within the scope of the information usually possessed by the engineer.

Due to these and other less obvious reasons, the present charts are of very limited value as a means of predicting the suitability of a steel for a given purpose or for comparing its merits for a particular use with those of another.

Frequency Curves Will Give Accurate Values

The proposed method overcomes most of the present objections and also offers the possibility in the future of a further development to include information not possible with the present graphs. Mr. Janitzky's paper brought out all of these points. The main need, I think, is to make it understood that for the present at least, the Standards Committee contemplates no serious changes in the charts as now published.

Briefly, the proposed method will consist of examining as many data obtained from commercial practice as possible; plotting the frequency with which the magnitude of any given property or combination of properties occurs in a given steel under the variable commercial conditions of manufacture and treatment and incorporating the



The accompanying chart is intended as a guide to the proper heat-treatment of this steel and to the physical properties that may be expected of a standard 0.505 x 2-in. test-specimen machined from rolled bars *up to 1½-in. diameter or square.*

Brinell and scleroscope hardnesses are taken at a distance from the center equal to one-half the radius and are not to be compared with surface readings on heat-treated bars.

For bars over 1½-in. diameter or square, this chart does not apply.

Typical Physical Property Chart

data so obtained in our charts. Some of the results will be low and some of them high; some may be very low, but such results will influence our final figures only in proportion to the frequency with which they occur. When such frequency curves have been properly interpreted mathematically, the results obtained will be accurate measures of what the steel is capable of doing.

The work in the Division is really only starting and we have not yet progressed far with it. The charts will be in the same form as they are now. The only difference will be in the method of getting the data from which to plot the new charts.

The Iron and Steel Division is in agreement that there are objections to the present charts but it fears there may be a lack of agreement among others. The whole subject has therefore been brought up to acquaint the industry with what we are trying to do to make the charts more correct and valuable and to arouse the industry's interest and cooperation by making any reliable data available for use by the Division.

How Former and Proposed Methods Differ

Vice-Chairman A. J. Scaife:—If there are any here who wish to discuss the physical property charts and give us any additional thoughts regarding them, we should like to hear from them.

F. P. Gilligan, Henry Souther Engineering Corporation:—The original S.A.E. Physical-Property Charts were developed by taking selected lots of steel supposed to represent the practice of a steel mill and subjecting them to standard heat-treatments. In doing this we took the maximum and the minimum values for a given carbon range, for example, 0.40 to 0.50 per cent carbon as in steel No. 1045. These curves are shown on the accompanying chart. The heats of the steels at the top of the carbon range and then at the bottom of the carbon range were selected and their physical properties determined for the different types of heat-treatment. Then the present S.A.E. curves for tensile strength and yield point, or elastic limit as some call it, were plotted for the bottom of the carbon range. For the elongation and reduction of area we took the minimum values also, selecting such values for the steels at the top of the carbon range permitted by the specification. Consequently, the present physical-property chart for any steel, as Mr. Chandler has pointed out, does not represent the minimum of all the physical properties of a given steel; it represents, for a given heat-treatment, the minimum tensile strength and yield point that can be expected from a steel at the bottom of a carbon range of a given specification and the minimum elongation and reduction of area of a steel at the top of the carbon range of the specification.

What we propose to do is to gather from the industry data on steels of given cross-section and known physical properties and prepare charts, as described in Mr. Janitzky's paper. Although individual data may vary, the frequency curves will become clearly apparent from a large enough number of tests for each S.A.E. steel. We shall be able to develop the maximum and the minimum values of a great variety of steels in actual service over a period of years rather than by a few laboratory tests. Then, by adapting these values to the present type of chart, we should be able to show physical properties within the range of steel composition permitted by the S.A.E. Specifications. It will permit us to develop more accurate charts. We can not do that now on some of the alloy steels, such as some of the chromium, vanadium and other higher types of alloys, because they require a narrower carbon range or can be heat-treated better with a narrower carbon range.

There seemed to be some misunderstanding and confusion at the Production Meeting last fall as to the purpose of all this work by the Iron and Steel Division. I think that was due to the fact that some of those present thought we were going to give them a new type of chart and ask them to work out the values by a mathematical formula. The whole proposal is merely to determine the facts and to enable us to do this, to ask you to dig into your files and give us the data that you have there. This will enable the Iron and Steel Division to provide physical-property data that are closer to the truth than ever before.

AERONAUTIC INSTRUMENT MOUNTINGS

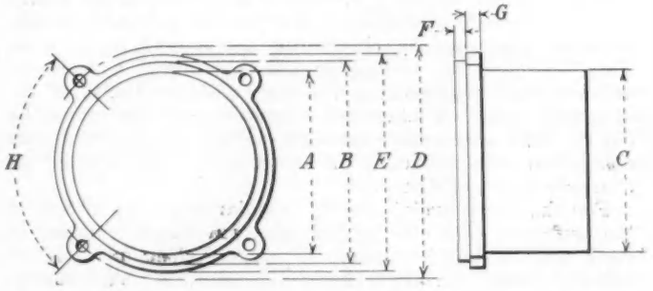
General Dimensions Studied by Subdivision and Their Publication Recommended

In accordance with the decision reached at the last meeting of the Subdivision on Instrument Mountings of the Aeronautic Division to assemble some general dimensions on which the mounting of aeronautic instruments depends, the following table has been prepared.

Several types of instrument are covered in this tabulation and the dimensions given are only those which would be of value in laying out an instrument panel. It is the recommendation of the Subdivision that these tables be approved and published as general information at this time, as no general mounting standard can be evolved until further developments occur.

The number of manufacturers making aeronautic instruments is very small, but it is felt that the publication of these data by the Society will provide a guide to airplane designers and will also be of interest to manufacturers who might in the future take up the manufacture of these types of instrument. Their value in this case would lie principally in preventing an adoption of a multiplicity of sizes owing to the lack of information on present designs.

Some consideration will be given by the Subdivision of the connections to the various instruments, and it may be possible to provide similar information on these features. The whole matter will be presented to the Aeronautic Division meeting which will be held in April.



Instrument	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Air-Speed Indicator Climb Indicator E. I. C. Indicator	3¾	4⅛	3.9	4 9/16	—	1/8	3/16	90
Turn Indicator	2⅜	2¾	2¾	3⅛	2⅞	1/8	3/16	90
Climb Indicator	2⅜	2¾	2¾	3⅛	2⅞	1/8	3/16	90
Fuel Level Gage	2⅝	3	2¾	3⅜	—	1/8	3/16	90
E. I. C. Controller	2¾	3 5/16	3 5/16	3¾	3⅜	1/8	3/16	90
Pressure Gages	1⅞	2¼	2⅛	2⅝	—	1/8	3/16	90
Tachometer								
Jones	3 13/16	4 5/16	3⅜	4¾	4¼	13/32	1/8	90
Van Sicklen	3 23/32	4⅛	4 9/64	4¾	4¾	3/8	1/8	90
Temperature Gage								
Moto-Meter	1⅞	2 5/16	2 5/16	2 13/16	3⅛	5/8	1/8	120
Pressure Gages								
National Gage	1⅞	2 5/16	2 5/16	2 13/16	3⅛	1/2	3/32	120
Altimeter	3⅜	3 23/32	3 9/16	4 7/64	4½	7/32	1/4	90

A—Dial diameter; *B*—Outside diameter; *C*—Back diameter; *D*—Mounting-Hole Circle; *E*—Flange diameter; *F*—Face to Lug; *G*—Lug thickness. All dimensions in inches. *H* is given in degrees.

HUGH T. WREAKS

AS THE result of a complete breakdown, thought by his associates to have been due to over-exertion in his work, and which forced him to give up his duties some days previously, Hugh T. Wreaks died on Dec. 7. At the time, he had been manager since 1915 of the Detroit branch of the Boston Insulated Wire & Cable Co., which he represented ably in every respect, winning the confidence of the company's customers in him as a sales representative and their esteem for him personally.

He leaves a widow, Mrs. Ella W. Wreaks, still resident at the home in Detroit and to whom the Detroit Engineering Society has extended the sympathy of its members.

Mr. Wreaks was elected to associate membership in the Society of Automotive Engineers in February, 1921. Born at Jersey City, N. J., in 1870, he was graduated by the Stevens Institute of Technology in 1890 with the degree of mechanical engineer. For the following 15 years he was engaged with the Westinghouse Electric & Mfg. Co. in various factory and field duties. During the following 10 years he occupied the dual position of manager of the Chicago Electric Protective Association and secretary of the wire inspection bureau. His third and final business connection, formed in 1915, was with the Boston Insulated Wire & Cable Co. Although graduated as a mechanical engineer, most of his experience had been along electrical lines and he was a member of the American Institute of Electrical Engineers, and contributed various papers on engineering subjects to technical periodicals.

Mr. Wreaks was an active member of the Detroit Section of the Society.

HARRY HARPER McCARTY

AN automobile accident that occurred while he was driving from Detroit to Cleveland resulted in the death on Jan. 29 of Harry H. McCarty, sales engineer for the Aluminum Co. of America and a junior member of the Society since October, 1922. He was single and is survived by his father, his mother and two brothers. Funeral services were held at the home of his parents in Lafayette, Ind.

Mr. McCarty was born at Lafayette in 1899, studied mechanical and gas-engine engineering at Purdue University and was graduated with the degree of bachelor of science in mechanical engineering in 1921 and master of science in mechanical engineering in 1922. He was a student member of the Society for nearly 2 years prior to his election with the grade of Junior Member. In his university work he concentrated on the problem of fuel knock in automobile engines, on manifolding and on carbureter design. In 1922 he took up work with the General Motors Research Corporation and was directly associated with Thomas Midgley, Jr., in the fuel department, where Mr. McCarty had charge of the building and installing of indicators in connection with the development of ethyl gasoline. He also occupied a position with the faculty of Purdue University in the department of practical mechanics and gas-engine design. His connection with the Aluminum Co. of America dated from February, 1926, when he accepted the position of sales engineer in the Detroit district, and he was a resident of Detroit at the time of his death.

Applicants Qualified

The following applicants have qualified for admission to the Society between Jan. 10 and Feb. 10, 1928. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member

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ZAKI, MOHAMMAD (F M) mechanical inspector, engineering section, Ministry of Agriculture, *Egypt.*

Applicants for Membership

The applications for membership received between Jan. 16, and Feb. 15, 1928, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALMEN, H. V., project engineer, powerplant section, General Motors Corporation, Research Laboratories, *Detroit.*

ALMQUIST, ERIC GUSTAF, draftsman, Curtiss Aeroplane & Motor Co., *Buffalo.*

ARLINGHAUS, FRANK H., sales engineer, Hyatt Roller Bearing Co., *Harrison, N. J.*

BARD, LIEUT. NATHAN WAYNE, U. S. N., student, Columbia University, *New York City.*

BARFORD, VALENTINE GEORGE, chief designer, J. I. Thornycroft & Co., Ltd., *Basingstoke, England.*

BARK, SYDNEY W., chief inspector, Chrysler Corporation, *Detroit.*

BARRY, RUTLEDGE B., salesman, Wood Struthers & Co., *New York City.*

BASTIEN, PAUL, in charge of engineering, Stutz Motor Car Co., *Indianapolis.*

BEHLEN, ALBERT, tool and plant engineer, Copeland Products, Inc., *Detroit.*

BERGER, BJARNE, engineer, Member Norwegian Government Motorcar Inspection Board, *Oslo, Norway.*

BERGER, MAURICE P., Ingenieur Directeur du Bureau de Normalisation de l'Automobile, Chambre Syndicate des Fabricants d'Accessories, 18 rue Tilsitt, *Paris* 17, *France.*

BECKWITH, DOUGLASS W., secretary and manager, Positive Lock Washer Co. of America, *Newark, N. J.*

BLOMSTROM, LOWELL C., assistant chief engineer, Federal-Mogul Corporation, *Detroit.*

BOEHME, CHARLES F., shop foreman, Smith Sauer Motor Co., *Chicago.*

BOHRMAN, IRVING GEORGE, draftsman, Waukesha Motor Co., *Waukesha, Wis.*

BOLTON, RUSSELL PHILIP, sales engineer, Long Mfg. Co., *Detroit.*

BOOM, CLIFFORD ARCHIE, general superintendent, Howard Auto Co. of Los Angeles, *Los Angeles.*

BOYNTON, ELLIS S., branch manager, Kings County Buick, Inc., *Brooklyn, N. Y.*

BRETLINGER, OWEN J., experimental dynamometer testing, Hupp Motor Car Corporation, *Detroit.*

BRITTON, LOREN D., chief draftsman, Servel, Inc., *Evansville, Ind.*

BROOKS, NEIL E., draftsman, Continental Motors Corporation, *Detroit.*

BROWN, H. FLETCHER, chief engineer, Eagle Iron Works, *Des Moines, Iowa.*

BURNS, THOMAS, mechanic in charge, Department of Street Cleaning, New York City, *Elmhurst, N. Y.*

CHALMERS, DAVID MEYLE, superintendent of service, Hansel & Ortman, *Stockton, Cal.*

CRAIG, CHESTER A., sales engineer, Ryan Sales Engineering Co., *Detroit.*

DALEY, THOMAS J., secretary and sales representative, Multibestos Co., *Walpole, Mass.*

DAVIS, ERNEST E., power transmission engineer, Dodge Bros., Inc., *Detroit.*

DAVIS, ROLLIN S., assistant body engineer, Ford Motor Co., *Dearborn, Mich.*

DAVISON, G. E., research and experimental work, Davison Engineering Corporation, *Richmond, Va.*

DEARTH, ELMER E., manager of product development, Fisk Rubber Co., *Chicopee Falls, Mass.*

DIEFENDERFER, VICTOR J., engineer, governor department, Bethlehem Fabricators, Inc., *Bethlehem, Pa.*

DILG, EARL W., engineering representative in production, Studebaker Corporation of America, *Detroit.*

DOBSON, DAVID A., garage superintendent, Jersey Ice Cream Co., *Lawrence, Mass.*

DOOLEY, ARTHUR F., service manager for New England District, General Motors Truck Co., *Boston.*

DREHER, MYRON A., tire design engineer, United States Rubber Co., *Detroit.*

FORWARD, DR. CHAUNCEY B., president, Oil Refining & Development Co., *Urbana, Ohio.*

GILBERT, ALVA B., draftsman, Ford Motor Co., *Dearborn, Mich.*

GIVEN, GUY C., research chemical engineer, E. I. du Pont de Nemours & Co., *Parlin, N. J.*

GRAHAM, ELMER J., superintendent of transportation, Public Service Co. of Colorado, *Denver.*

GRISELL, L. HOBART, chief engineer, Gar Wood, Inc., *Detroit.*

HALPINE, LIEUT.-COM., CHARLES GRAHAM, U. S. N., aeronautic engine laboratory, Naval Aircraft Factory, *Philadelphia.*

HAMON, ALFRED JOHN M., equipment manager, E. L. Phillips & Co., *New York City.*

HAWKES, A. G., body engineer, American Car & Foundry Motors Co., *Detroit.*

HERBERG, ERIK, assistant test engineer, Hyatt Roller Bearing Co., *Harrison, N. J.*

HERBERT, FRED C., development engineer, United States Rubber Co., *Detroit.*

HERZ, FRED B., chief draftsman, radiator division, Long Mfg. Co., *Detroit.*

HIERTA, HANS, draftsman, Lincoln Motor Co., *Dearborn, Mich.*

HUNT, B. B., maintenance foreman, Union Ice Co., *Oakland, Cal.*

IMLACH, JOHN STEVENSON, manufacturer of garage equipment, 55 Wilton Crescent, *Ottawa, Ont., Canada.*

JAMES, WILLIAM M., works manager, Kearney & Trecker Corporation, *West Allis, Wis.*

JENSEN, OTTO H., research engineer, Bossert Corporation, *Utica, N. Y.*

JONES, CLARENCE WILLIAM, detailer and minor layout, Eaton Spring Corporation, *Detroit.*

JUPP, W. B., chief rail car engineer, International Motor Co., *Long Island City, N. Y.*

KIRK, J. N., sales and advertising manager, World Bestos Corporation, *Paterson, N. J.*

KIRSCHNER, HENRY J., chassis designer, Hupp Motor Car Corporation, *Detroit.*

KNAPP, LELAND G., manager of merchandise research department, Montgomery Ward & Co., Inc., *Chicago.*

KOENIG, FRED, service manager, American Car & Foundry Motors Co., *Detroit.*

KROHA, LAWRENCE J., sales engineer, Harry Bros. Mfg. Co., *Detroit.*

KYSER, HOWARD N., junior laboratory engineer, Studebaker Corporation of America, *South Bend, Ind.*

LAWSON, IVER NORMAN, JR., secretary-treasurer and engineer, Ryan Aeronautical Corporation, *San Diego, Cal.*

LEVY, JAMES, assistant body engineer, Hupp Motor Car Corporation, *Detroit.*

MADINCEA, JOHN, draftsman, Chrysler Motor Corporation, *Highland Park, Mich.*

MASON, FOREST L., head of automotive department, Quincy Industrial School, *Quincy, Mass.*

MATHAUER, EDMUND GEORGE, designer, American Car & Foundry Motors Co., *Detroit.*

MAUNSEL, RICHARD, engineer, Stanley Automotive Products, Inc., *Detroit.*

MCCOOK, ARTHUR A., supervisor of motor vehicles, New York Telephone Co., *New York City.*

MCINTYRE, CHARLES S., president and general manager, Monroe Auto Equipment, *Monroe, Mich.*

MILLER, CARL D., professor of physics, Washington College, *Chestertown, Md.*

NACKER, O. M., engine development engineer, Cadillac Motor Car Co., *Detroit.*

NEWTON, H. L., engineer, Vacuum Oil Co., *New York City.*

NICHOL, HAROLD I., superintendent of transportation, Staten Island Edison Corporation, *Staten Island, N. Y.*

NICHOLSON, GRIFFITH C., vice-president and engineer, Hydro-Check Corporation, *Monroe, Mich.*

NIEMAN, HENRY W., experimental engineer, Bethlehm Steel Co., *Bethlehem, Pa.*

OLMSTEAD, CHARLES ALLEN, assistant foreman, Chevrolet Motor Co., *Tarrytown, N. Y.*

OTTON, ALFRED S., advertising manager, Moto-Meter Co., *Long Island City, N. Y.*

PANKRATZ, A. C., manager and president, Quality Aluminum Casting Co., *Waukesha, Wis.*

PIERSON, CARYL FOOTE, salesman, Leigh M. Railsback Co., *Los Angeles.*

POLLAK, JOSEPH, general manager, Joseph Pollak Tool & Stamping Co., *Dorchester, Mass.*

POLLARD, R. SPOTSWOOD, sales engineer, Wheeler Reflector Co., *New York City.*

POSTAL, A. E., general service manager, United Motors Service, Inc., *Boston.*

QUIGLEY, ARTHUR H., vice-president, American Brass Co., *Detroit.*

RAABE, ARTHUR E., salesman, Eclipse Machine Co., *East Orange, N. J.*

RATH, FRED, tool designer, International Motor Co., *New Brunswick, N. J.*

RICHARDS, HOWARD R., development engineer, Cleveland Tractor Co., *Cleveland.*

RITTER, WILLIAM C., assistant to factory manager, Long Mfg. Co., *Detroit.*

ROSAN, JOSE, designer, International Motor Co., *Long Island City, N. Y.*

ROYSTON, JOSEPH R., secretary, treasurer and works manager, American Nut & Bolt Fastener Co., *Pittsburgh.*

SCHLESINGER, AUGUST B., designer, American Car & Foundry Motors Co., *Detroit.*

SCHMIDT, FRANK W., chief engineer, Jaxon Steel Products, *Jackson, Mich.*

SCHROEDER, KARL, managing director, Durkopp-Werke, *Bielefeld, Germany.*

SHARPE, B. M., service manager, Stanley W. Smith, Inc., *San Francisco.*

SIMPSON, O. H., dynamometer laboratory testman, Hupp Motor Car Corporation, *Detroit.*

SMITH, WALTER S., general manager and factory manager, Gar Wood, Inc., *Detroit.*

SPRINGER, RAY W., vice-president and general manager, Superior Felt Products, Inc., *Flint, Mich.*

STANLEY, FRANK J., works manager, Michigan Steel Casting Co., *Detroit.*

SUTTON, JAMES A., chassis layout draftsman, American Car & Foundry Motors Co., *Detroit.*

TAFT, BURTON M., vice-president and general manager, Reo Michigan Sales Co., *Detroit.*

VAN DE BERGHE, PAUL, engine investigator, Mack International Motor Co., *Long Island City, N. Y.*

WARD, LEWIS S., draftsman, American Car & Foundry Motors Co., *Detroit.*

WATTS, WILLIAM S., checker in engineering department, Bendix Brake Co., *South Bend, Ind.*

WESSELHOFF, CLARENCE E., chief draftsman, Ford Motor Co., *Dearborn, Mich.*

WITTMER, CLARENCE E., student, University of Michigan, *Ann Arbor, Mich.*

YOUNG, CLARENCE M., director of aeronautics, Department of Commerce, *City of Washington.*

CHATEAU FRONTENAC, QUEBEC, THE SCENE OF THE 1928 SUMMER MEETING